P/
Tech
12
47
502

THE

JOURNAL

OF THE

Franklin Institute,

DEVOTED TO

Science and the Mechanic Arts.

EDITOR

WILLIAM H. WAHL, PH. D.

ASSISTED BY THE COMMITTEE ON PUBLICATION.

THIRD SERIES.
VOL. LXII.
WHOLE NUMBER. VOL. XCII
July—December, 1871.

PHILADELPHIA:
PUBLISHED BY THE FRANKLIN INSTITUTE AT THEIR HALL.
1871.

INDEX.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

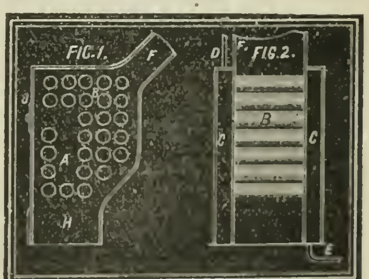
PROMOTION OF THE MECHANIC ARTS.

VOL. LXII.] JULY, 1871. [No. 1

EDITORIAL.

ITEMS AND NOVELTIES.

An old Example of a "new" Boiler.—We present herewith a "cut" and description of one of the forms of steam boilers--the tubulous—upon which so many changes are at present being rung, and to which the name of "new" is given. If not the first, it is certainly an early record of the tubular grate-bar and of the tubular fire-wall combined with perfect water circulation. This apparatus was used for heating water.



The tubes B B are secured to and connect the side-box spaces C C together. A pipe E conducts the water to the bottom of one box, and a pipe D from the top of the other box, through a system of heating pipes returning to the pipe E again.

Fire is placed in the space A through the fire door J: H is the

ash-pit and F the flue for escape of gases.—*Marquis de Chabannes, London*, 1818.

J. H. C.

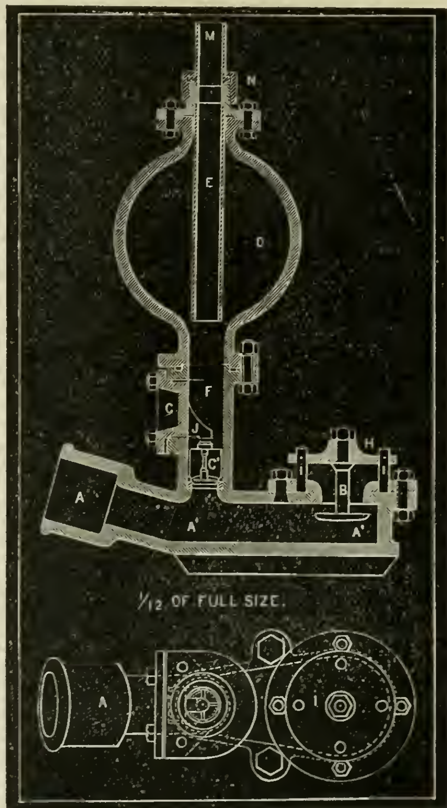
The Equilibrium Disk for lightning rods, is the name by which an invention of Prof. Burleigh's is known, and is designed, according to the inventor, to increase many times the inductive power of the lightning rod. The accompanying engraving gives a view of the new attachment which formed the subject of a very commendatory report from the Institute Committee on Science and Arts, at one of its recent meetings.

The usual size of the disk is two feet in diameter. Its weight, including the seventy-two horizontal and perpendicular discharging points, is about 40 pounds. It is made of one of the common metals, though copper is preferred. Iron, however, being cheapest, is generally used. Regarding the mode of using it, it is stated that it should be sunk into the ground deep enough to be surrounded by perpetual moisture, rarely less than six feet. By exact adjustment, the rod passes through its centre, and is firmly solidified to the disk by copper surrounding.

A new Niagara Bridge at Buffalo.—The Acts of Congress and of the Dominion Parliament have authorized the construction of a new Bridge across the Niagara at Buffalo. The Act authorizing its construction makes it a post route. The work will be under the superintendence of the directors of the Grand Trunk Railroad.

The Delaware Bridge.—The obstacles which have stood in the path of this important enterprise have at last disappeared, and there is every prospect that before the year has expired the work upon it will be energetically in progress. The original plan of a draw, which met with some objections on the part of the Examining Board, has been finally abandoned, and the plan of an elevated bridge, offered by Thomas S. Speakman, chief engineer, has met with approval.

An Hydraulic Ram.—Water enters the ram at A, and flows along the horizontal part A′ A′, escaping through the valve opening B. The valve plate H, secured to the valve stem, is guided vertically by 4 pins I. The valve C′ opens upwards into the vertical pipe F, which communicates directly with the base of the air-vessel D, and may be removed and replaced through the hand hole C; it is checked in its upward opening movement by a projection J on the cover C. A pipe E conducts the water from the base of the air-vessel to the exit pipe M, whence it is conveyed by pipes to the place where it is wanted.



The case A, cover C and air-vessel D are of cast iron; the valve B, plate H, and its seat, the valve C and its seat, and the coupling N and nozzle M are of brass. The pipe E is of wrought iron. The engraving is to scale $\frac{1}{12}$ size. J. H. C.

"Of the many and various situations where these rams are in use, I will only mention that the railway projectors, Messrs. Brassby, Baxton & Co., have in this way furnished different stations on the Tadela and Bilboa Railroad, in Spain, with water, and have thus saved the annual recurring expense of coals, workmen, and repairs of engines and pumps.

"In relation to the question of cost it may be remarked that the expense is, when compared to the manifold advantages it affords, in no respect proportional. Indeed, under the given conditions, the principle of the hydraulic ram is the most practical, the cheapest

and most efficient for elevating water that can be devised. It also affords the assurance to the improvers of property of an abundant supply of water when in danger from fire, as well as for the convenience and beautifying of the house and garden—so essential in our day to the comfort of an agreeable homestead.

Tabular Statement of the Different Sizes of Rams.

	Diameter of Supply Pipe.	Diameter of Main Exit Pipe.	Average Duty in Twenty-four Hours.
No. 1	$1\frac{1}{2}$ inches.	$\frac{3}{4}$ inches.	300 to 500 gallons.
2	2 "	1 "	800 " 1200 "
3	$2\frac{1}{2}$ "	$1\frac{1}{2}$ "	1500 " 2500 "
4	3 "	2 "	3000 " 4000 "
5	4 "	2 "	4000 " 6000 "

"It must be remarked that for every gallon of duty afforded by rams, from 8 to 10 gallons of fall water are necessary."—*C. F. Jessen, in "Der Practische Maschinen Constructeur."*

The Detroit Tunnel.—From various sources we learn that the project of constructing a tunnel beneath the Detroit river seems now to be in a fair way to be realized. If completed, it will be the most extensive engineering work of its kind in this country, or, probably, elsewhere. Upon the plan at last approved by the Company, the length of the work between the extreme portals is to be 8568 feet. It is to be built in two separate parts, which are to be cylindrical in form and fifty feet apart: the design being to avoid in this way any interruption to the passage of trains—it being presumable that an accident would be confined to but one of the compartments.

A Pneumatic Sounding Apparatus, acting in a manner analogous to a barometer, was recently described before the Institution of Naval Architects, by Mr. W. C. Bergius. The principle on which it operates is that it indicates and registers the maximum hydrostatic pressure to which it has been subjected, and is therefore independent of the movement of the ship, or of the amount of slackline overboard.

A new Ice Machine.—The plan of M. Mignot, a French inventor, by which it is proposed to utilize the cold produced by the

dilation of compressed air, for the artificial production of ice, has recently found application in practice. A machine upon this principle has been built in Manchester, England, for a London manufacturer, but as yet nothing relating to its performance or efficiency as compared to the other well known ice-makers, has been made public.

Coating Brass with Copper.—Dr. Puscher* dissolves for this purpose 10 parts, by weight, of sulphate of copper and 5 of sal ammoniac in 150 parts of water. The brass, well cleaned and free from grease, is dipped and left for a minute in this mixture; it is then removed, allowed to drain for a moment, and heated over a charcoal fire until ammoniacal fumes cease to be given off—when the film of copper is perfect. It is simply washed with water. The copper coating is said to cling firmly.

Earthquake Statistics for 1870.—Prof. C. W. C. Fuchs, in his yearly report, records for the year 1870, one hundred and thirty-one earthquakes. Mexico, Japan, Greece and Italy seem to have suffered considerably from these unpleasant visitations. In the latter country alone, from this cause, 99 persons were killed, 222 were wounded, and 2225 houses were destroyed. But one phenomenon of this kind is accorded to the United States, and this is one, too, of a mild character. It occurred on the 20th of October, was most perceptible in the Eastern States, lasting but 20 seconds, and confined its performances to dislocating a few houses.

The Heliotype Process.—The art of reproducing photographic images rapidly and cheaply by a mechanical printing process is being steadily developed; and we may at no distant day expect to see it brought to such practical perfection as to take the place, in a great measure of the lithographic process now in almost universal use.

It was discovered some years ago, that a film of gelatin saturated with bichromate of potash acquired, on exposure to light, certain properties, which have since that time to the present taxed the ingenuity of numerous observers to utilize. The most important of these properties is, that in those parts where the light has acted upon such a film, it will take up greasy ink, precisely like a lithographic stone, while the parts unaffected by light will absorb water. A number of photo-lithographic processes depending upon this property for their efficiency have been from time to time announced;

* Bay. Ind. u. Gewerbe Blatt, *Feb.*, 1871.

but few, if any, appear to possess all the qualifications requisite for extended adoption in practice.

The Albertype process, discovered by Albert of Munich, is one of the latest and best. In this, a plate of moderate thickness is coated with a thick film of liquid bichromated gelatin, which is subsequently exposed to the light to render it insoluble. This is then coated with a thin coating of sensitive gelatin, which is exposed to the light beneath the negative which it is desired to reproduce; from this film thus obtained, which is rendered indifferent to further change by washing, most excellent prints are obtained by the lithographic process.

The Heliotype process,* the latest development of the art, differs from the one just described, in a number of details, by which greater toughness, durability and freedom of manipulating films is secured. Mr. E. Edwards, the discoverer of the process, adds alum to his bichromated-gelatin solution, and finds that by this addition, while the sensitiveness and subsequent ink-absorbing property of the films are not the least impaired, they possess, to a far greater degree than has yet been obtained, the property of swelling but very slightly in water, and the power of resisting the action of the printing press.

The gelatin films are spread on finely ground glass plates, which are so prepared by polishing with wax as to admit of their subsequent removal. The films, carefully dried, are exposed beneath the negative. The impressed films are then washed in the dark room and caught on zinc plates. To these the films are firmly attached by pressure, by which at the same time all remaining traces of free bi-chromate are removed. The films thus prepared are ready to undergo the printing process. By varying the consistency of the ink, it is possible to print in two colors; the stiff ink affecting only the portions most changed by the light, while the thin will take hold of the half tones. After use the films are removed from the zinc plates and preserved for future printing.

On the transmission of the Sound of the Human Voice by rods of English Deal. By Prof. Edwin J. Houston.—An interesting modification of Wheatstone's celebrated experiment of the Telephonic Concert was recently tried at the Central High School of Philadelphia. A rod of English Deal, about twenty feet in length and three-quarters of an inch thick was let down through a

* For detailed accounts of the history and successive stages of this process, see *Journal of Photography* and *Nature*, Vol. IV, p. 85.

platform into the room below. Insulation from the platform and the ceiling of the lower room was obtained by enclosing the rod with small sections of thick rubber hose, against the lower end of the rod the sounding box of a small tuning fork was placed. On speaking or singing into the open end of this, the sounds were transmitted by the rod to the room above, the volume of the sound being increased by placing a guitar on the upper end of the rod.

The experiment is exceedingly interesting and striking. Although the interval between the notes is perfectly preserved, their intensity and quality are changed very decidedly, the effect being similar to that produced by ventriloquism. As the position of the rod is immaterial, striking effects can be produced as though by ventriloquism. A small figure placed on the end of the rod or on the sounding box adds greatly to the effect. A song is transmitted in a very amusing manner. As it is preferable to have the sounding box held so that the pulses should impinge in the direction of the length of the rod, the experimenter in the room beneath rested for convenience, on a settee. This mode of transmission of sound does not, of course, give as good results as by means of hollow tubes, as the transmitted sound cannot be heard at as great a distance. It is, interesting, however, from its novelty.

New Spectroscopic Combination.* By P. A. Secchi (in a letter to Prof. Silliman, dated Rome, April 19, 1871).—I have the honor to announce to you the discovery of a new spectroscopic combination, by the aid of which one can see the images of the spots and of the solar protuberances, with the spectral lines all at once in the same field.

This result is reached by two methods: 1st, by placing before the objective of the telescope a prism as large as that which I employ for star spectra, say of six inches opening, and causing the colored image which is produced at the focus of the lens to fall upon the slit of the ordinary spectroscope.

2d. The other method, less costly, consists in placing a direct-vision prism of a high dispersive power in the path of the luminous rays before they arrive at the focus, and over the slit of the common spectroscope.

By these two methods is obtained in the field of the spectroscope, the solar image formed of different colored shades, with their spectral lines, but very sharply defined with their spots and margins

* *Am. Jour. of Science,* June, 1871.

quite exact, so that the details of the spots can be examined as with a colored glass.

If the sun's limb falls near the line C, which as we have just said, is seen at the same time as the image of the sun's limb, we see the chromosphere and the prominences showing themselves as brilliant lines more or less elongated from the sun's limb, according to the height of the prominences. The narrower the slit the sharper the image of the spots.

Thus the protuberances are seen as brilliant lines, but their form is recognized only by linear sections as in the old method of Janssen. Nevertheless their height can be perfectly recognized and measured by measuring the distance from where the line C becomes brilliant to that point on the snn's limb, which is upon the same normal to the limb. By opening the slit the form of the protuberances can also be recognized, but only with a loss of precision of definition. By a narrow slit the height and position of the protuberances can be recognized and measured with the greatest precision, and their position fixed with reference to the spots and faculæ, in a manner far more simple and certain than with the ordinary spectroscope.

If in a spot there is a jet of hydrogen, C is at once seen to become more brilliant, or at least the darkness is diminished, and the lines of calcium and of iron become broader, &c., as in ordinary observations, but with far greater satisfaction and certainty of position.

I have observed the spectrum of the little comet of Winnecke, and I have found a band in the green similar to that in the other comets.

The Physical Constitution of the Sun.—A recent paper by Prof. Norton* contains an elaborate discussion of the subject heading this notice. Perhaps the most interesting portion is that which relates to the origin of the sun's flames or protuberances, and the corona, to which the attention of astronomers and physicists, has of late been so closely directed. In connection with this subject, Prof. N. announces as highly probable the declaration of Faye, that the slow process of cooling going on at the solar surface has the effect of reducing the temperature to such an extent that certain vapors having a strong affinity for oxygen will enter into union with this element. The compound molecules thus formed will possess a greater weight in comparison with the repulsion to which they are

* *Am. Jour. of Science*, June, 1871.

exposed, and will therefore descend more or less rapidly into the photosphere. No further visible effect would be produced were this the whole process; but it is highly probable that the descending masses would arrive at a depth where the higher temperature would effect a dissociation of the combined elements.

This sudden dissociation of combined elements, though occurring at considerable depths within the photosphere might, according to the author, play an important role at the solar surface. He considers it probable that under certain circumstances these dissociated elements would be urged upward by repulsion, and pass with greater or less velocity through the several envelopes. Hydrogen should, accordingly, rise to the greatest heights, and should make its appearance in sudden outbursts above the chromosphere. In support of his proposition, the author adduces the announcement of Lockyer, who detected in the solar protuberances a velocity of 120 miles per second, and a height of 40,000 miles, and of Prof. Respighi, who has even detected in such a prominence an elevation of 160,000 miles above the sun's photosphere.

The idea is likewise advanced that the corona, which has been traced, with the aid of the spectroscope, by various observers, as far as 425,000 miles from the sun's limb, may be due to a substance several times lighter than hydrogen, in which solar repulsion might predominate over the attraction of gravitation, urging the subtle fluid from the sun in all directions.

A Nitro-Glycerine Explosion.—Dr. E. F. v. Gorup-Besanez mentions in a late exchange* an account of the explosion of 10 drops of nitro-glycerine, which took place in his laboratory, and which, from the astonishing effects produced, is well calculated to give one a most respectful notion of its explosive properties. One of the Doctor's pupils, in the course of an investigation, placed the quantity of nitro-glycerine mentioned in a small cast-iron saucepan, which was heated over a small Bunsen-burner.

The effect was, that forty-six panes of glass in the laboratory were broken to pieces, the iron pan was hurled through a brick wall, the stout iron stand on which the vessel had been placed was partly split and partly twisted out of shape, and the tube of the Bunsen-burner was split and flattened. Fortunately, none of the persons in the laboratory at the time were injured. The author in this connection, calls to the attention of his readers a communi-

* *Chemical News.* Notes from foreign sources.

cation of Dr. E. Kopp on the conditions under which this substance explodes or quietly burns. When caused to fall, drop by drop, on a full red-hot iron plate, it burns off like gunpowder; but should the iron plate not be thoroughly red, yet hot enough to cause the nitro-glycerine to boil suddenly, an explosion invariably occurs.

Separation of Combined and Graphitic Carbon.—Boussingault* describes a new method of accomplishing the separation of the combined and graphitic carbon in iron analyses, which, from its simplicity, is worthy of mention. Though the absolute separation and determination of these two important constituents of iron is not possible by any analytical process yet devised, the one about to be mentioned affords the analyst an easy method of determining the relative quantities of readily oxidizable and difficultly oxidizable carbon contained in a sample, which is a matter of great importance to the practical chemist.

Boussingault treats his irons with bi-chloride of mercury, and heats the residue thus obtained in the air to a temperature not exceeding dull redness. The combined carbon is by this means totally consumed, and may be determined by the loss in weight: while the graphite remains behind unchanged. The quantity of this latter is to be estimated by combustion in a stream of oxygen, in the usual manner.

Though no mention is made of the fact, we may infer that the treatment with mercuric chloride is for the purpose of converting the iron, with its accompanying metallic constituents, into soluble chlorides; that these are then extracted by digestion with distilled water, and that the residue then remaining, which would consist of silica and the two kinds of carbon, is the residue referred to, which is to be heated in the air, &c. In the original paper, the caution is added to heat the residue, after each combustion, in an atmosphere of hydrogen, to reduce to its normal condition any traces of iron which might accidentally have been mechanically retained in it.

Reduction of Chloride of Silver.—Dr. Graeger, in a communication to *Dingler's Journal*, states that the use of metallic zinc, for the reduction of chloride of silver, is greatly to be recommended; inasmuch as it affords a silver much purer than that obtained by the wet process of reduction now in use.

Combustion under Water.—An experiment which we believe will be new to some of our readers (and perhaps interesting) is a

* *Ann. de Chim. et de phys.*, *XX*, 243.

simple and brilliant method of showing to an audience the phenomenon of combustion under water. The ordinary mode of leading a jet of oxygen upon phosphorous melted under water is attended with a few inconveniences, the chief of which, if we except the disagreeable necessity of handling this unreliable substance, are the short duration of the phenomenon and the great liability of the breakage of flask, from the intense heat produced at the point of combustion. The experiment to be described is free from all these inconveniences, and is, from the experience we have had with it, entirely superior to the one mentioned above. If the ingredients for the well known Red Fire are taken, and the strontium and potassium salt, but especially the former, before the mixture is made, are thoroughly dried upon the sand-bath, the mixture will be found to burn under water, if first ignited before being plunged into it, with quite a brilliant effect, throwing a glow of light in all directions. The best form to be recommended is to make a cone or cylinder of glazed or silvered paper, to fill this tolerably tight with the well-dried mixture, and close the base so as to be impervious to water. To be used it may be attached to the end of a wire, ignited at the point and plunged into a large jar of water, where it will burn with much energy until exhausted.

Necrology.—By recent advices from England we learn of the death of one of the most talented of young British mechanical engineers. Mr. Ferdinand Kohn has a reputation among engineers as author of a well known work on "Iron and Steel Manufacture," and as an able contributor to our valued contemporary *Engineering*.

He was a Bohemian by birth, and was educated in the Austrian technical schools. After some practice in Austria, he removed to London, where he has since remained.

He has taken an active part in the introduction of Bessemer's, Siemens', and other valuable processes, and was appointed by Austria to report upon the Paris Exposition.

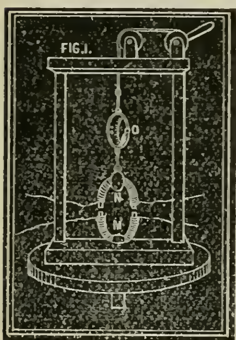
We had the pleasure of meeting him in London a few months since, and his learning and his practical knowledge of all European processes of iron manufacture made him an invaluable, while he was also an exceedingly pleasant acquaintance. He was an enthusiastic admirer of American institutions—except, of course, our tariff—and was hoping that an intermission in his pressing business engagements might enable him to visit the United States and study our methods.

Mr. K., by careful preparation in the School of Technology and

by a wide and keen observation of actual practice, had combined to an unusually fortunate extent high scientific attainments with great practical knowledge. He was an excellent representative of the advanced school of modern mechanical engineers. His personal character was admirable, and in his death his friends and the profession have experienced a very great loss. R. H. T.

Arsenic in Aniline Dyeing.—The dust of some print works, in which aniline colors were printed by acid of arsenate of soda and acetate of alumina, has been analyzed by Bolley, who found it to contain quite a perceptible quantity of arsenic. The method of testing was the ordinary one, with Marsh's apparatus.

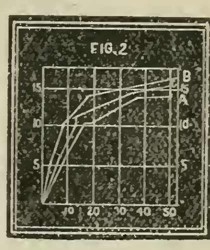
The Lifting Power of Electro-Magnets has generally been assumed to be proportional or very nearly so to the power of the current employed. From some accurate experiments of Von Waltenhofen with apparatus shown in Fig. 1, it appears that this is true only within very narrow limits as will be seen from the tables where the same horse shoe electro-magnet is used with three different armatures, and where *s* is the measured power of current *p*, the corresponding degree of saturation produced in the unarmed magnet, as measured by its influence on a magnetic needle and L the lifting power measured in kilogrammes.



Armature A.			Armature B.			Armature C.		
S	p	L	S	p	L	S	p	L
16·29	3·01	1·97	16·3	3·10	5·37	15·87	3·31	3·75
28·11	5·77	4·17	37·40	7·15	8·97	27·34	5·57	6·15
35·29	6·79	4·92	45·55	8 74	10·27	37·33	8·12	7·35
45·55	8 91	6·27	91·05	17·60	13·87	59·95	12·86	9 90
89·35	17·78	10·27	236·28	49·75	16·24	62·85	13·52	10·90
96·86	18·98	10·27				101 02	21 95	12·82
130·01	24·85	11·37				163·09	35·44	14·50
188·77	38·29	14·02				213·95	46·20	15 50
246·53	51·39	14 42						
249·23	52·12	14·42						

The armature A is an electro-magnet precisely similar to the magnet experimented with, but with no current passing through it. B is the armature A charged by the same current as the expe-

rimental magnet. C is a piece of soft iron rounded semi-cylindrically on the side resting on the magnet. In the graphical representation, Fig. 2, made from these tables by taking the degrees of saturation as abscissas, and the lifting power as ordinates, the curve for the armature C runs between the magnetized and unmagnetized horse-shoe armatures; and all three show a pretty rapid convergence to an asymptote parallel to the axis of abscissas, representing a maximum of lifting power of about 18 kilogrammes. It will also be observed by examining the columns of p and L that the observed lifting powers approach this maximum at a strength of the electric current, which in the unarmed magnet only produces about half the saturation.



The influence of Violet Light in stimulating vegetable and animal growth. A pamphlet recently presented, by request, before the Philadelphia Society for promoting Agriculture, by Gen. A. J. Pleasanton, contains a detailed account of a series of experiments conducted during ten years, on the above subject, the results of which are quite surprising.

Impressed with the belief that the actinic qualities of the more refrangible rays—blue and violet—of the spectrum might be practically employed to stimulate the development of life, the author constructed, as early as March, 1861, a grapery in which every eighth row of glass was violet-colored. In this, cuttings of some twenty varieties of grapes, each one year old and of the thickness of a pipe-stem, were planted. We are informed that within a few weeks after planting, the walls and inside of the grapery, which was 84 feet long, 26 feet wide and 16 feet high at the ridge, were closely covered with the most luxurious and healthy wood and foliage. A number of vines of the same varieties and age, which had been planted in a grapery of ordinary construction, had some months later acquired but a trifling growth. In the fall of the next year the vines bore the immense yield of 1200 pounds of grapes, the bunches being of unusual magnitude. In 1863 the yield was two tons, and the yield has continued, without symptoms of decay or exhaustion of the vines, until the present time.

The success of the experiment with vegetable life induced the author to try the plan upon the development of animal life, and though the results obtained were by no means so surprising as in the former case, they were still quite marked. He informs us that he has succeeded in developing into full size, and with all the functions of maturity, in the space of fourteen months, a bull calf so puny and feeble at its birth that it was not expected to live.

The results here announced are surprising, though they afford an additional and beautiful confirmation of the announcement long since made upon the functions of the various portions of the solar spectrum.

Editorial Correspondence.

Dr. Wahl:

My Dear Sir—Several months ago I stated to you that a mineral specimen had been sent me for analysis, which proved to be metallic antimony, and I enclosed, with the statement, a fragment of the substance sufficient to substantiate the fact. The sample sent me weighed about an ounce and a half, and I had hoped at that time, from the representations and promises made to me, to have been able soon to furnish you with a better specimen and with a fuller account of the discovery, location, probable amount of the mineral, and other facts relating to this very interesting substance. But, thus far, I have been unable to verify the statements made me, or to obtain the additional specimens freely promised at the time the above specimen was forwarded me for analysis, although it was represented that it was a portion of a mass weighing about twenty pounds.

I would regard the whole matter as a hoax, and an attempt at fraud, were it not that certain facts render its truth probable, and that the appearance of the mineral corresponds so decidedly with the distinctive features of native antimony. In view of the indefinite character of the information on all points, nothing more than a superficial examination was made, but I trust that, in a short time, duly substantiated statements will be obtained. It is certainly to be regretted that any uncertainty should attach to so interesting a mineralogical phenomenon. I have reason to believe that samples of the mineral were furnished to other parties about the same time, and you may receive confirmatory accounts from other sources.

Charles F. Himes.

Dickinson College, June 10th, 1871.

Note.—The sample which was received from Prof. H. in his former letter was sufficient to give all the blowpipe tests for its recognition as metallic antimony. As the Professor remarks, it is to be hoped that the uncertainty concerning the origin of his specimen will soon be removed by more definite information. Should his suspicions be verified, the occurrence would be of a most interesting character.—Ed.

Civil and Mechanical Engineering.

ON THE USE OF PULVERIZED FUEL.

By Lieut. C. E. Dutton, U. S. Ordnance Corps.

(Continued from Vol. LXI., page 385.)

The economy of high temperatures over low ones (provided they are obtained without enormous increase in the consumption of fuel, and provided also, they are not so great as to act destructively upon the materials subjected to them), is vastly greater than would at first seem, and out of all proportion to the increase. It is an unfortunate fact, that the temperatures at which the operations of heating and puddling are performed, approach near to the extreme temperature attainable in the flame from the grate. After the fire has been in operation a few hours, the temperature of the roof, walls and bath of metal, will be equal to that of the flame, less the temperature lost by conduction through the walls. At high temperatures this loss is known to be very great, and is proportional to the time occupied by the gases in passing from the fire-place to the throat. If the flame have the maximum temperature due to that mode of firing, then the only way in which it is possible to increase the temperature of the bath of metal is to increase the volume of gases passed through the furnace, and the consequent velocity with which they pass; we then diminish the time, diminish the proportional losses of heat and temperature—thus bringing the temperature of the bath nearer to that of the flame. But the proportional increase of temperature thus obtained is much below the proportional increase of fuel expended.* This is illustrated daily by unskilful, ignorant heaters, who send through the hearth immense volumes of flame and gas, under the impression, no doubt, that the

* Let $q =$ the quantity of heat required to raise the temperature of the gases to 2500°. Say the temperature of the bath is 2200°, in which case 300° is lost by radiation, or $q \cdot 12$. We desire to raise the temperature to 2300°, in which case the loss would be $\cdot 08\, q'$. This can be effected only by making q' much larger than q. The proportion $q' : q :: .12 : \cdot 08$ would be insufficient, because the rate of loss at 2300° is greater than at 2200° by about $\cdot 06$; making the proportions $q' : q :: \cdot 12 \times 1\cdot 06 : \cdot 08$, or $q' = q \frac{\cdot 12 \times 1\cdot 06}{\cdot 08} = q \times 1\cdot 59$. In other words, requiring 59 per cent. more heat. As the temperature of the gases is assumed to be the same in both cases, the increase must be in their volumes, which represents a corresponding increase in the quantity of fuel burning. [The temperatures selected are arbitrary, and for purposes of illustration only: still, the foregoing estimate approximates to the real facts of the case.]

effect produced is directly proportional to the quantity of fuel consumed, while, in reality, very little, and sometimes no increase of temperature is obtained. The efficiency of heat, or the rapidity with which its effects are communicated, are related in a complex ratio to the difference between the temperature of the radiant and that of the recipient. For a given difference it varies in an increasing ratio with the absolute temperature of the two elements.

Let us apply these considerations to the various stages of the puddling process. The first stage, where the iron is melted, may be materially shortened by the more intense heat of pulverized fuel. In the second, or boiling stage, time is required to perfect the chemical reactions, and its duration cannot be materially shortened by any amount of heat. Moreover, it is desirable to boil at the lowest temperature consistent with perfect fluidity. But the much greater temperature obtainable by the use of a given supply of coal, in the form of dust, enables us to reduce the rate of consumption very materially, and yet preserve a sufficient temperature. In the third, or balling stage, where the highest temperature is required, we may attain it by a much smaller increase of consumption than would be necessary by the grate-burning method. In the heating furnace, also, the advantages of increased temperature of the flame are equally conspicuous, since they materially shorten the time of an operation, and obviate the necessity of increasing enormously the consumption of fuel, in order to obtain the last increments of heat in the pile.

We may observe here the operation of a general law of thermal physics, that the rapidity of thermal action due to given differences of temperature; is greater at high temperatures than at low ones, and hence when we add to our command of it we increase in two ways: we increase the number of our units and augment largely the value of each unit. Hence we account, by means of simple physical laws and familiar facts, for the greatly increased effects of small additions to high temperatures. We are also prepared to consider entirely just and reasonable the claim put forwerd by Messrs. Whelpley and Storer, of a very large economy obtained by their process, in the expenditure of fuel in the operations of the reverberatory furnace. They state that in a practice extending over eight months, the use of a pulverizer attached to a double puddling furnace has given a general average consumption of 1250 pounds of coal to the ton of puddle bar. It is usual to estimate ordinary pud-

dling at a ton of coal to the ton of iron, in which case pulverized fuel would give an economy of forty-five per cent. of the amount at present used. Large as this claim may seem, every theoretical and practical consideration with which I am familiar, leads me to the belief that it is entirely rational and intrinsically probable.

But Messrs. Whelpley and Storer have not only demonstrated in their experimental furnace at Boston, that a much higher temperature is attainable by the use of pulverized fuel than by the grate-burning method, and this with less coal; but they have also obtained, at moderate cost, a temperature comparable to that obtained in the Siemens furnace. This will not appear at all surprising when we come to examine the facts of the case. The temperature of the Siemens furnace is not by any means so high as is usually supposed by those who have never investigated it. By whatsoever method this investigation be conducted, it will readily appear that this temperature cannot be more than 350° to 400° F. above that of the common reverberatory furnace used for heating, and is probably less even than that—say 2500° to 2550° F. This applies, of course, to the ordinary temperature of that furnace, when making steel, which may be melted at about 2500° F. That the temperature cannot be more than slightly above this melting point is clear, from the great length of time required to attain complete fusion. M. Ch. Schintz has also shown, by an elaborate calculation of the amount of heat carried into the regenerators and returned to the gases, that this should be the approximate temperature, and has verified his calculations by long and careful experiments. When we compare gas burning with dust burning, we may readily find abundant reason to expect, that by the addition of hot blast we may easily obtain in the reverberatory furnace a temperature fully equal to the Siemens. Messrs. Whelpley & Story heat the air blast by means of a stove quite similar in principle and general structure to that employed for blast furnaces, and located beyond the throat of their furnace, where it is heated by gases issuing from the hearth. Now, in the Siemens furnace the fuel is half burned, or more than half burned, in the generators, and the gases purposely cooled down in the great flue, in order to give them propulsion, and to condense the hydro-carbons, which would otherwise clog the regenerators. The heat so dispersed is a total loss, and it includes that derived from the perfect combustion of the greater part of the hydrogen, which has the highest thermal equivalent of any elementary sub-

stance; so that the entire heat of the hearth is derived from the combustion of nearly pure carbonic oxide, plus the heat received from the regenerators.* But pulverized fuel yields to the hearth the entire thermal equivalent of its compounds, which fact must go far towards compensating the effect of the regenerators; and we can easily compensate the remainder by heating the air blast, and this with the same expenditure of fuel as by the Siemens method. I see nothing in this application of hot blast which does not appear to be entirely practicable and simple.

I am able to certify that I have seen the foregoing results amply verified at the experimental furnace of Messrs. Whelpley and Storer, at Boston. There were charged upon the hearth 200 pounds of pig iron, which was melted in 17 minutes, to which were added successive charges of wrought iron scrap, amounting to 800 pounds, and the whole was tapped off in two hours and fifty minutes from the time of charging the pig iron. The ingots contained only about $\frac{25}{100}$ per cent. of carbon. The consumption of fuel was 177 pounds per hour of bitumiuous coal and anthracite slack, mixed in the pulverizer, and 29 pounds of anthracite culm in the fire-place. The hot blast stove was a mere temporary and imperfect affair, at no time above a just perceptible red heat, and yielding a blast certainly not above 450°; whereas, it might be made to yield readily 800° to 900° at the tuyere. Indeed, the temperature at command by this method is limited only by the ability of the furnace materials to withstand fusion, and this temperature is attained by burning a much smaller quantity of fuel than is required in the old reverberatory heating furnace for obtaining a welding heat.

The kind of fuel employed is an important consideration. The best results are obtained with bituminous coal. In common grate burning, anthracite usually gives a more intense heat than soft coal, although its thermal equivalent is theoretically less. But in burning soft coal, the distillation of hydrocarbon vapors from the upper layers of the fire absorbs considerable heat, and as these are subsequently burned only very imperfectly, and with great loss by smoke, much of the thermal power of this coal is lost. In the reverberatory furnace the long flame of bituminous coal is required to fill the hearth, while anthracite would yield only an intense heat in the

* The heat developed by burning C O to C O² should be greater than by burning C to C O, because in the latter case much heat becomes latent by vaporization, *i. e.* the conversion of a solid into a gas. The differences of specific heats are also in favor of the former.

fire-place, and a flame short and of small intensity in the hearth. With pulverized fuel the full, long, abundant flame, and the great temperature due to the higher thermal equivalent of bituminous coal, are both realized—a fact abundantly sustained by practice, and and in itself a proof that the combustion is more complete.

But very good results are attainable with anthracite, the chief ob-objections to it being that it requires more power to pulverize it, and that it does not ignite so readily. A slight admixture of bituminous coal will quicken the ignition very materially. Preparatory to pulverizing, the coal must be reduced to gravel, so as to enter the machine easily. This is done in a breaker or crusher, which is run at very small expense; a single crusher being sufficient for a large mill with many furnaces.

There remains to be considered what modification of the chemical effects of the flame would attend the use of pulverized fuel in the reverberatory furnace. There are certainly differences in the conditions under which the oxidizing or reducing influences of the flame are exerted, as compared with the old method. In the case of pulverized fuel, we have the entire mass of the coal, ashes and all, passing through the hearth. In some parts of the hearth we have free carbon and free oxygen uncombined, which sweep over the surface of the bath, and occasional particles falling into it. Somewhat similar conditions, but less in degree, attend the use of solid fuel, and I cannot but think that the effect of the pulverized fuel in carbonizing or oxidizing the metal will be determined by the conditions of the flame itself, *i. e.* whether oxygen or carbon preponderates. Although there is commonly present in the furnace both free oxygen and free carbon, yet the probabilities would seem to be that the metal would still be deoxidized when the oxygen is in any degree in excess of the demands for combustion, and would be carbonized when oxygen is deficient. In the case of puddling, the metal is powerfully protected by the supernatent slag. In heating iron piles, a neutral flame is obviously essential, and it would seem as if such a flame, charged with particles of solid carbon impinging against the soft white mass, would carbonize it. But if this were actually the case, how does it happen that the piles are not carbonized in the old way by the smoke, which abundantly fills the whole hearth, and is pure carbon in a spongy state, almost molecularly subdivided, and, therefore, seemingly in a condition most favorable for the production of this very effect. If such action can

take place any where, it certainly ought to take place in the puddling furnace immediately after balling, and just before the balls are drawn. The purified iron is then not only rolled up out of the slag, and naked to the flame, but is in that peculiar spongy state in which it exposes a very great surface to it, and is at the same time exposed to the highest heat. The abundant experience hitherto had with pulverized fuel shows no such action, and with a properly managed flame it probably does not occur. As to the use of this fuel for melting wrought iron and steel in open hearths, experience has not yet been sufficient to warrant a conclusion in this regard. In the experiments it would seem that the iron was carbonized to some extent, but the flame was overcharged with fuel.

II. *The use of pulverized coal in generating steam.*—The foregoing considerations are, with suitable modifications, applicable to boiler practice. As every fuel has the power of generating by combustion a fixed quantity of heat—a quantity which it is at present impossible to convert into its maximum useful effect by any method—the problem therefore becomes a question as to what is the method which will enable us to approach most nearly to this maximum useful effect. Part of the potential heat is never developed, because not all of the carbon and hydrogen can be oxidized, or rather peroxidized. Part of the heat developed by combustion is carried out at the chimney, and lost altogether, thus failing to exert any useful effect by absorption into the boiler. Part of the heat absorbed into the boiler is lost by radiation from the external shell before it can be converted into work in the steam cylinder—and so on; each source of loss being very serious, and robbing the engineer of a large per centage of his resources. The ultimate store of power which he is able to convert to actual uses is but a small per centage of the whole amount originally contained in his fuel. The use of pulverized coal involves a striking economy by the prevention of loss from two of the sources just mentioned, viz., from imperfect combustion and from failure to absorb all the heat generated. It does not indeed prevent *all* losses from these causes, but materially reduces them. The defects of the grate-burning method have perhaps been sufficiently discussed. Many attempts have been made to overcome them, and some valuable improvements have been accomplished, the most important of which are devices for admitting air over the fire. But, inventions intended to regulate the supply of air in conformity with the progress of combustion in the coals,

and those intended to consume smoke, have fallen into general disfavor, so far as economical results are concerned. They all involve inconveniences or losses which more than compensate their advantages. The essential conditions upon which a real economy of combustion must be founded are well enough understood, but the difficulty of attaining them has been inherent in the defects of the mode by which air and fuel are made to react upon each other. The admission of air over the grate is only a partial remedy, and fails to effect the one all-important condition of instantaneous and perfect intermixture. Considerable quantities of smoke and carbonic oxide have always been, and always must be, carried from the grate through the flues into the atmosphere, so long as this mode of firing is continued. But a source of loss quite different from imperfect combustion will appear when we come to examine into the conditions attending the transmission of heat from the gases to the heat-absorbing surfaces and interior of the boiler. In order that heat may be transmitted from one material to another, it is necessary that the temperature of the two be different, and the rate at which it is transposed will be a positive function of this difference. Again, the transmission of heat through a plate of metal requires time, and the longer the heat-giving body is in contact with the plate, the more heat will be transmitted. It has been stated that the average amount of air supply to the grate is at least twice the theoretical quantity necessary for complete combustion. This amount is found practically to give the best results, on an average, with that method of firing. Let us assume, as no doubt can be easily shown in practice, that the air supply for pulverized fuel need not be more than fifty per cent. in excess of the theoretical minimum. We have at once a diminished volume of escaping gases, and a corresponding increase in their temperature. In effect, then, we have a largely increased difference between the temperatures of the two sides of the plate, and an increased transmission. But this is not all. The rate at which heat is transmitted, increases in a higher ratio than the difference of these two temperatures. For example, let us take two cases, one of a plate whose interior surface is in contact with water at 250°, and its exterior in contact with gases at 1000°; the other of a plate whose interior is in contact with water at 300°, and its exterior in contact with gases at 1300°. Now, not only will the transmission be absolutely greater in the second case than in the first, by reason of the wide difference of temperature in the two sur-

faces, but it will be *greater for each degree of difference.* Again, a reduction in the volume of gases implies a corresponding reduction in the velocity with which they pass through the flues, and therefore increases, in the same ratio, the time during which they are in contact with the heat-absorbing surfaces.

It must be borne in mind that the advantages here indicated are not peculiar to pulverized fuel alone, but are applicable to all flames of a high temperature. The superior economy of high temperatures over lower ones (so long as they are not destructive to the boiler or fire-chamber) is a principle susceptible of the fullest demonstration.

The foregoing discussions are by no means wholly new. The principles and facts involved in grate-burning have long been understood to be substantially as stated, and have been practically assumed in all rational attempts to construct smoke-burning fireboxes. Mr. Bourne, in his great treatise on the steam engine, has illustrated and discussed them in his descriptions of numerous contrivances for this purpose. The abatement of the smoke nuisance is one of the great problems of English mechanical engineering, having been made the subject of innumerable patents and several parliamentary investigations. But such investigations seem to have ended just where they began—in smoke. Hence, no doubt, Mr. Bourne was led to make the following significant statements: "Nearly all the expedients hitherto introduced for burning smoke in locomotives, are adaptations of the devices heretofore in use for burning smoke in land-engine furnaces. But the rapid combustion which a locomotive boiler requires, renders the burning of smoke by any of these ancient devices a matter of very difficult achievement, and it seems to be indispensable that a method founded on a totally new principle should be introduced. It appears to us that the fuel and the air must be fed in simultaneously; and the most feasible way of accomplishing this object seems to be in reducing the coal to dust and blowing it into a chamber lined with fire-brick, so that the coal dust may be ignited by coming in contact with red-hot surfaces after having been mingled with the quantity of air necessary for combustion. This, however, in common with other improvements upon the locomotive, requires to be worked out."

The foregoing discussions have been based upon the assumption that the conditions of burning pulverized fuel are realized in the manner calculated to yield the best results. The present stage of this invention lacks, as yet, some few requisites of completeness,

and is by no means without practical difficulties. Of these, the most important relates to the manner of igniting the dust. It would seem that, in order to be perfect in its action, the flame of the fuel should be self-sustaining, and keep up the ignition steadily from the mouth of the tuyere, without any adventitious aid from a gas generator. If the gas generator be removed while the fire is under full headway, there will be no falling off in the flame at first. On the contrary, if the supply of air be regulated by the requirements of the coal, the heat will be more intense, but at the same time the point of ignition will slowly push forward into the furnace, and the brickwork around the tuyere, being thus removed from or abandoned by the flame, will cool down. Now, it might seem as if this could be remedied by diminishing the velocity with which the fuel and air are poured into the furnace, which might be done by increasing the aperture of the tuyere. Supposing this to be practicable, instead of having a constant position where the ignition would commence, that position would be one of unstable equilibrium, in which a slight variation of circumstances would cause the flame either to advance into the furnace or recede into the pipe. In a word, it is necessary to determine definitely the point of ignition, and there seems to be no way of doing it better than by bringing the coal in contact with burning gas. Now, the generator, which accomplishes the ignition, is otherwise detrimental to the highest effect of the fuel, since, so far as it goes, it reproduces all the disadvantages of grate-burning, with its excessive supply of air, which takes up heat and diminishes temperature. But since it is made very small—as small, indeed, as practicable—its effect is correspondingly small in diluting the effect of the fuel. It is to be hoped, however, that the rare ingenuity of the inventors will enable them to discover some equally certain means of igniting the fuel without even these small disadvantages.

In conclusion, there is appended the statement of Messrs. Whelpley & Storer, of the work performed by their pulverizers.

"The 18-inch pulverizer, commonly applied to furnaces, reduces 200 pounds per hour of anthracite coal, the proportions of size being about like the yield of mill-stones. It requires about 3½ horse-power to effect this. The same power reduces 300 pounds of bituminous coal, a large proportion of it being very fine. The entire yield will burn easily, wafted through a hot furnace. A 42-inch pulverizer, requiring about 15 horse-power, will deliver 1000 to

1200 pounds of anthracite per hour, 2000 pounds of bituminous coal, 2500 to 3000 of quartz, 2000 to 2500 pounds of top cinder, 3500 to 4000 pounds of limestone, 900 pounds of unburned bone, and 50 bushels of wheat. With an increase of power we have ground one bushel of wheat per minute, finer than is done with mill-stones, and 6000 pounds of copper ore in limestone gangue."

"A comparison of these figures with stamp-work, or any other method of pulverizing, would show very great economy, whether in cost of machines, attendance, wear and tear, or power consumed."

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from Vol. LXI, page 315.)

Cutting.—"In the sweat of thy brow shalt thou eat thy bread," was the judgment pronounced against man. A kind Beneficence has, however, so constituted mankind that his normal condition is one of labor; and, instead of a judgment, labor and industrial activity is the greatest of human blessings.

The materials of nature that are needed for our comfort and existence are not placed in our hands ready for use, but have to undergo processes and a "making up" to adapt them to our wants.

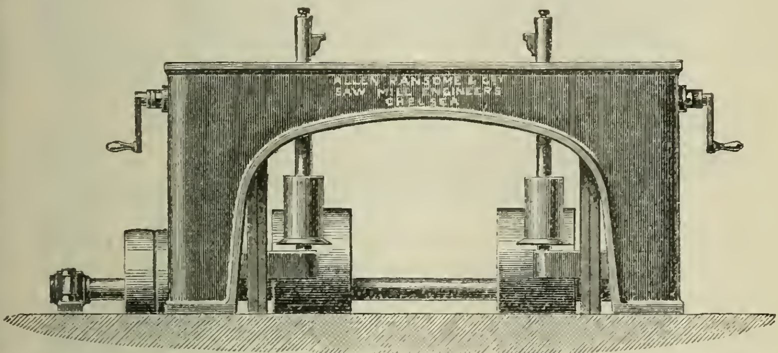
In those things that are continually essential, and without which we could survive but a brief time, nature has kindly adapted them more nearly to our wants, without previous preparation. Air, that is momentarily needed, is not left contingent upon our exertions, but is free to all, and ready for use. So with water, which needs but transmission to where it is wanted. In this we see a wise purpose. These things are too important to be left to anything so uncertain as human effort to prepare and change.

Not so with our food and clothing and other wants. We must have an agency in their preparation. They are furnished to us in a crude form, to be worked out by skill and manual effort, directed by our intelligence.

To ameliorate the laborer's toil, that would otherwise be needed in converting these crude products of nature to our uses, we are supplied with the natural forces, taking the place of our hands.

Steam alone has relieved man of nearly all his drudgery. It produces his clothes, his food, transports him from place to place, exchanges the products of various parts of the earth, so that in each part is enjoyed the benefits of the whole. Glance around a room fitted with the comforts of life, and see if there is anything that does not in some manner owe its origin to steam. Not a thing will be found—books, paper, even the ink and pen with which we write, the very buttons on our clothes—but can be traced back to this mighty agent of production.

Fig. 1.



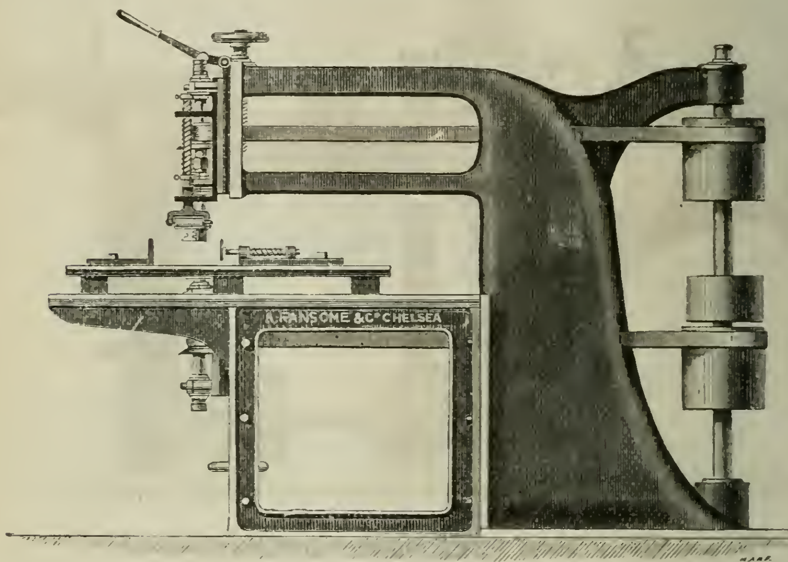
Wood and metals, to which our attention is here more especially directed, come to us in such a crude state that but little if any benefit can be gained from them until wrought by our industry. The trees in the forest or the ores in the earth are far from contributing anything in a direct way to our wants; they must be grappled with by force, and by the light of science be artificially wrought into the thousands of forms that we see around us.

To come to something more practical after these general propositions, it is proposed to consider the cutting and shaping of metal and wood as constructive material.

The processes are surprisingly simple when considered in the abstract. For metal we have molding and compressing the material in a malleable or melted state, removing the surplus by means of the wedge or cutting tools, and by abrasion. The latter can, no doubt, in a sense, be considered the same as cutting or the wedge action, if followed to a nice distinction, but for the sake of classification will be spoken of as a separate means of shaping material. By molding and forging accurate dimensions can be obtained. The

excessive heat and expanded condition precludes any certainty of dimensions when the metal cools, even if other conditions were favorable; hence the process is but a preliminary one at best, in which an excess of metal must be allowed to be cut away.

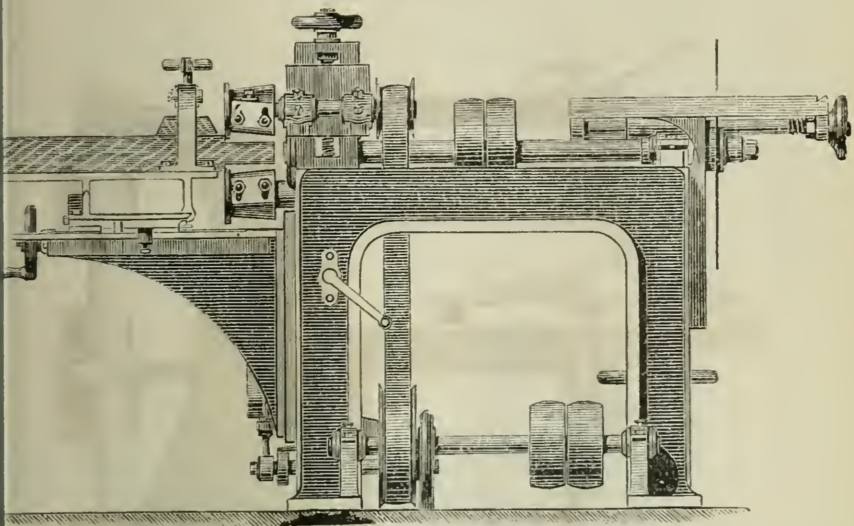
Fig. 2.



In shop practice there has not been (so far as the writer knows) any data from which to draw conclusions upon the relative cost of preparing or shaping by means of cutting tools as compared with grinding, which we will, for distinction, class under the general head of "abrasion." It is true that when material is too hard to be cut we grind it—with sand, emery, or by frictional abrasion—from necessity; but supposing, for example, that we have 10 pounds of soft steel to remove from a cylindrical shaft, or from a plane surface, "is it cheaper to cut it away with wedged tools or to grind it off?" This is not a chimerical proposition, but one that enters directly into practical manufacturing. The writer, in 1864, built a machine for grinding, that corresponded in its functions to the metal planing machine. The stones used were seven feet diameter by 12 to 16-inch thick; the traversing carriage was 8 feet long, 18 inches wide, weighing about 1 ton. This carriage was mounted on rollers, and had a reciprocating motion of 6 feet per minute, equal in speed

each way. The mechanism corresponded in general to that of an iron planer, or as near as practicable, considering the peculiar arrangement that was necessary to protect the movable joints and bearings from the sand and grit.

Fig. 3.



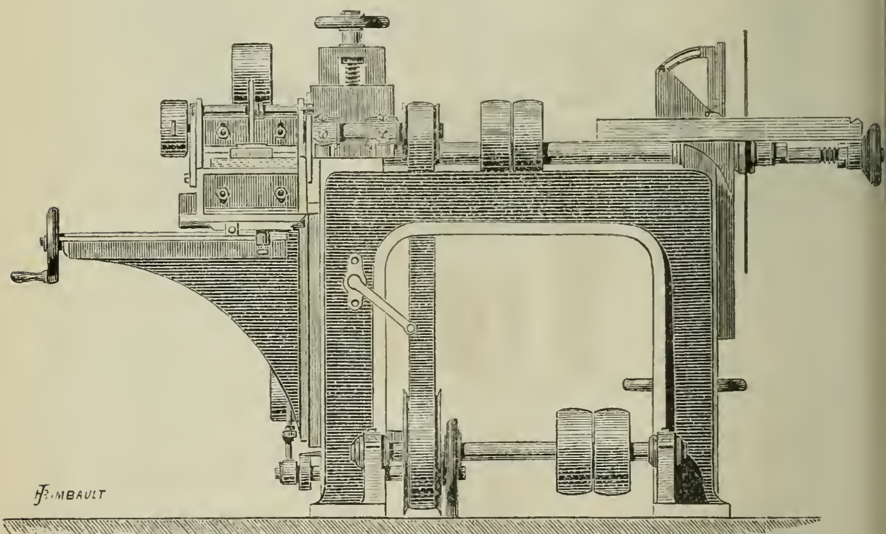
The surfaces ground were from the forge, composed of soft iron and hard steel, two-thirds of iron to one of steel, covered with a heavy scale from oxidization in welding. The material was ground to a true plane surface, and left with a polish that could not have been attained by cutting tools, even if the material could have been so worked.

This machine has been constantly at work since that time, grinding from 75 to 100 superficial feet per diem.

It is, of course, impossible to institute any comparison between this performance and that of a planing machine, unless we assume some specific work to be done, and whether the work is to prepare plane surfaces, removing only the irregularities of rolled plate or bars, or whether it is to cut away a large amount of material. Assuming, however, that the same pieces could have been planed, the work performed is at least eight times as much as could have been done with cutting tools on a planer. To offset this we have the greater amount of power used, say 25 to 1, the wear of the stone amounting to $2·50 per diem, or as much as attendance—the greater room

needed for grinding machinery, its dangers, and the very serious objection of the sand and water that finds its way all over the shop—the rapid wear that cannot be avoided in such machines; so that there is, after all, perhaps, nothing gained in grinding plane surfaces that can be planed. A popular impression exists that it is much cheaper to grind than to turn or plane soft iron or steel—a mistake that will soon prove itself where the displacement of material amounts to anything that could be called a "cut" for tools. It grows, no doubt, out of the fact that the speed is not limited, as with tools, and that a greater amount of work can be done in a given time with the same attendance. This is only possible because of the conditions being such as to avoid heat, as it certainly costs more to cut away iron by disintegrating the particles by abrasion, reducing it to a powder, than to "wedge it off" in large pieces.

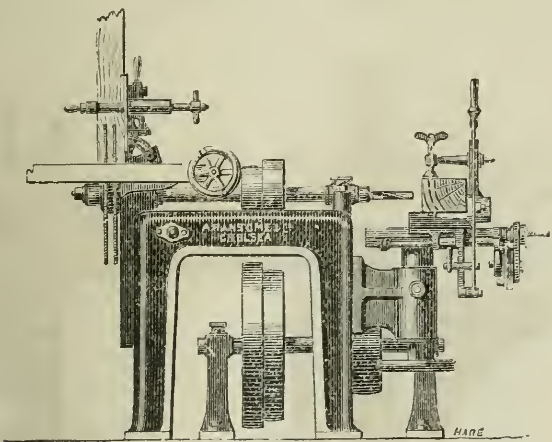
Fig. 4.



The "wedge" is man's great agent in converting the materials of nature to his uses. In working wood we can neither grind nor forge; all operations are simple cutting, and the wedge alone can be used. From the felling of trees by means of the axe down through the thousands of forms into which it is wrought, the cutting edge is the only means of dividing and shaping wood. The whole system of wood cutting machines represents only the various plans of applying the wedge.

It is both curious and interesting to resolve simple munipulation into this somewhat abstract proposition of a wedge, but it is true, nevertheless, and the most important deductions in practical matters are not unfrequently drawn from such propositions. In a recent law suit, involving a large expenditure of money and time, the position of the defendant was based upon a supposable difference between a cutter head and a circular saw. One of the suits growing out of an infringement upon the famous Woodworth patent, in wood planing machines, was from a similar mistake. Now, had this proposition, or rather fact,-of all wood-cutting tools working on the same principle, been understood, or even suggested, a great loss of money and time could have been avoided.

Fig. 5 (front.)



Again, considering all wood-cutting machines as acting on the principle of a wedge, it leaves but two essential conditions to be determined, in order to find what kind of cutters are best adapted for any special kind of work: first, the angles of the cutter; and, second, the relation between the edge and the course of the fibre. The teeth of a saw, for instance, that is used for cross-cutting, require to be very different from one that is used for slitting. The cutting principle is the same—the simple wedge—in both cases; but the question of fibre comes into play. The lateral adhesion of wood fibre is comparatively weak, and but little force is required to split it off when the ends are severed. This is illustrated in the process of splitting wood longitudinally into fire-wood or fence-rails. In

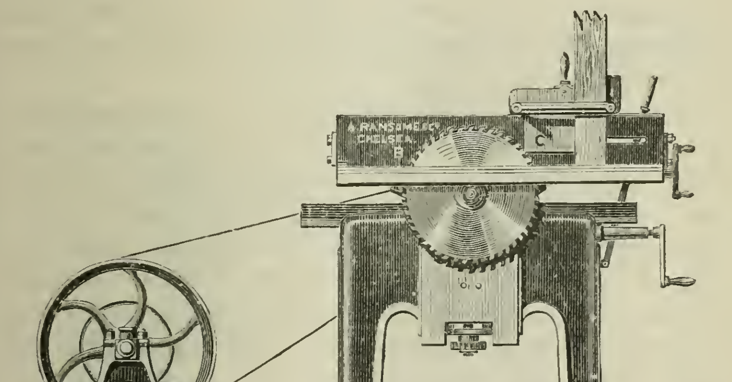
the saw for cross-cutting the teeth must be so arranged as to sever the fibre at the end before removing particles. In slitting, the teeth must be arranged with reference to severing the fibre across the width of the kerf with each tooth. To do this with the least power, the angles of the tooth must be as acute as possible, must correspond to the action of a chisel for mortising. As a general rule for all cutting edges in wood work, they should be as thin or acute as possible, the degree, of course, being governed by the hardness of the wood and the transverse strain that may fall upon the edge. Following out our hobby of the wedge, without any attempt at connection, it will be remarked, that vessels for navigating the water furnish another example of its importance. A vessel, to carry a certain amount of load, must have a certain amount of immersed section. This we put into the general form of wedge, to divide the water. The more acute the wedge, the more efficient its action. Projectiles, as now made, conform to the "wedge law," in that the wedge is the great mechanical power, man's chief ally in combating and overcoming the obstacles of nature. Levers, pullies, explosive agents, hydrostatic apparatus, all have their places, but the wedge is paramount, the king of all.

Shaping Machinerg.—The term shaping has, by consent and custom, been adopted to define all wood working machines that cut irregular forms, that is, lines that are neither straight nor yet true curves. Considering the importance of such machinery in the manufacture of gun-stocks, lasts for shoes, oval sections for the handles of tools, &c., it is to be wondered at that no attempt had been made to do such work by machinery until about 1820, when the Blanchard Lathe, in some form, appeared in the United States. In 1822, John Parker Boyd, of Boston, Mass., patented in England "Certain improvements in machinery, for shaping or cutting out irregular forms in wood or other material or substances which admit of being cut out by cutters or tools revolving with a circular motion, whether such motion be 'continuous' or 'reciprocating.'"

The machine illustrated in the drawings that accompany the spefication in this patent (No. 4652) show what is known as the handle-lathe, constructed in all essential points as it is now made. We refer to the English patent instead of the American, for the reason that it is *available;* and it will be proper in this connection to say, that while the abstractions of patent law are so thoroughly considered there it would be as well to study the plan which the British Go-

vernment and continental countries have adopted to give publicity to patent inventions. Certified copies can only be procured here after delay, and by paying from ten to twenty times their worth. For this reason it has been found necessary in these papers to use, as far as possible, English patents for reference, which, we feel ashamed to acknowledge, are more accessible, and, as a rule, are much more clear and comprehensive in their specifications. The writer can confidently state, from his own experience, that it is easier to examine ten patent specifications in the British Office than a simple one at Washington, where there is but a simple drawing and single copy of the description, and these, strange to say, kept in separate rooms. It is true some reform has been made by the recent innovations—the specifications are printed and the drawings photographed; but why not throw the whole thing aside—compile and print our specifications and lithograph the drawings, as the

Fig. 5 (side.)



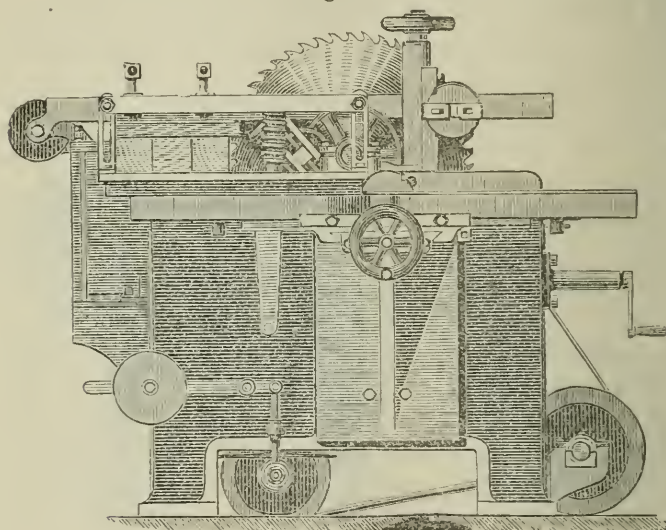
English do? The saving to the country in litigation that would be avoided in a single year would go far towards paying the expense.

To resume. Irregular shaping consists in producing duplicates with a cutting tool and tracer that have coincident movement. Duplicating machines would be a better and more comprehensive name for tools of this kind, and should be adopted. For turning handles, gun stocks, lasts, &c., the material is placed in a swinging lathe that has a radial motion on a pivot. The vibrations of the lathe are produced by a duplicate of the piece to be cut, which revolves in con-

tact with a guide or tracer that corresponds to the cutters, acting on the piece to be worked. In the later and best modifications of these lathes, the cutters vibrates and the material revolves on fixed centres—the principle being the same, with the advantage of vibrating a lesser weight. If the digression will be excused, we will here note that there is an obvious law of construction disregarded in many machines in this respect of relative movement.

Always move the parts that have the least weight, is a rule that will be found right in nearly all cases. When the material is heavier than the tools, move the tools, and vice versa. There are, of course, other conditions beside weight or resistance to be considered; still, the rule is a good one, and applies, with but few exceptions, to all other wood machines as well as the eccentric lathe.

Fig. 6.



Duplicating from patterns by means of cutters and guides was, during the term of the Boyd or Blanchard patent, subject to a tax from the users, whether in the form of the swinging lathe or with moveable tools, and it is somewhat strange that during the first term of that patent, the principle, as we will term it, did not come more into use. The shaping machine has always been regarded as a distinct invention, although its performance is much the same, except that it cuts in a constant plane. Fig. 1 is an edge-shaping, machine, a true front elevation $\frac{1}{2}$ inch to 1 foot, from the designs of

the manufacturers, Allen Ransome & Co., of London, England, who have kindly furnished many engravings which have from time to time appeared in these articles. This machine has recently been modified and improved, and another engraving will be presented in a future number of the *Journal.* The spindles have a vertical adjustment by means of screws and gearing, operated by the cranks shown on the right and left of the cut. The spindles are reverse motion right and left; weight, 3000 pounds; cutting speed, 4000 feet per minute. The cutters, it will be noticed, are passed through slots in the spindles, which gives a cutting angle too obtuse for soft wood, but has claims for convenience and simplicity that quite balance this fault, especially where a great variety of cutting is done—a single cutter being used. The common plan in this country is to use two duplicate cutters on each spindle, held by clamping collars that are screwed down upon the edges or ends of the blades, by which arrangement a perfect "balance" is maintained, and the angle of the edge can be more acute.

Fig. 2 is a side view of a machine of the same class, from the same manufacturers, that has two spindles, one above and one below the piece. This machine is adapted to such a variety of uses that it would be impossible to enumerate them here. There is scarcely any shape that cannot be attained, either for ornamentation or fitted surfaces. Carving in relief is, however, the main object, a work which is rapidly performed in a very perfect manner. The design is a good one. The great "overhang" of the spindle throws a heavy torsional strain on the main column or support, which is peculiarly constructed in order to withstand it. The weight is 3000 pounds.

Figs. 3, 4, 5 and 6 are true elevations of combination machines for joiner work, manufactured by Messrs. Ransome & Co., of London. They are capable of doing an endless variety of work by changes of cutters, and the complex adjustments that have, by experience, been from time to time added. Their work is, however, in straight lines. Mortises, tenons, grooves are made; sawing, planing and molding can be done. In fact, the requirements of a small shop or the "odd jobs" in a large shop can all be done on the general joiner, as it is termed, with great facility.

(To be Continued.)

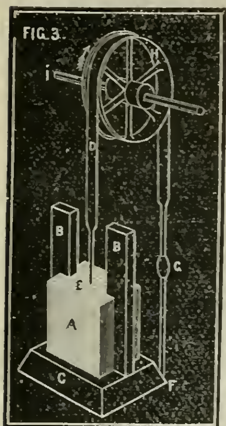
BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from Vol. LXI., page 319.)

The belt offers a simple and efficient means of producing intermittent effects, as in that of operating stamps, when it is desirable to control by the hand the number of blows in a given time, as well as to vary the intensity of the same at will. Arranged in this manner it acts as a friction clutch.

In Fig. 3, the shaft J, which may be the main line of the shop, or a counter shaft, carries a flange pulley H, continuously revolving in the direction of the arrow. Over this pulley is thrown loosely a belt D, one end of which is fastened to the stamping weight A at E, and the other end is secured to the floor at F.



The weight A is guided in the parallel uprights B B, and rests upon the base C. As the apparatus stands, the weight A is not lifted, owing to slackness of the belt, but by taking hold of the belt at G by the hand, and drawing it forcibly in a horizontal direction and at right angles to the shaft, a severe tension is created in the belt on the pulley, which latter lifts the weight at a velocity nearly equal to that of its rim; releasing the belt from the hand destroys the tension, when the weight falls freely back to the base.

It is evident that the number of blows struck may be repeated at will, and that the force of the blows, in so far as they may be due to the height of the fall, may also be regulated by the duration of the lateral pull on the belt.

Since the effect of the lateral pull on G is as G F + G H, and becomes less as it leaves the straight line joining H and F, it is important to make the distance H F as great as may be convenient, and to keep the belt as taut as can be without destructive friction on it at the pulley surface when not in use.

For the lighter hand stamping operations, this is a simple, cheap and ready means of obtaining gravity effects on dies and molds.

The Lincolne Belt-fastener.—"The disadvantages, such as insufficient strength and loss of time attending the usual mode of fast-

ening belts by means of sewing or of leather laces, are well known. What worker in a mechanical workshop has not had to do with the comparatively tedious operations of lacing a belt? Several mechanical belt-fasteners are now in use. One of the newest and most ingenious forms, affording a very strong and yet light joint by very simple means, is that which we now illustrate. It is a Canadian invention, and we understand that, though of very recent introduction, it is making rapid headway, both in England and abroad. The fastener consists of two pieces of tough curved plate (Figs. 1 and 2), tinned, to preserve them from oxidation. The buckle proper is curved, as shown in the cut (Figs. 1 and 2), and formed with a series of teeth at each side, its width transversely to the length of the belt being rather less than the width of the belt itself.

FIG. 1.

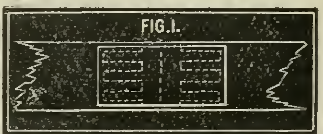
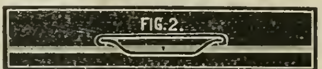


FIG. 2.



The ends of the belt are pierced with an awl, or a special tool for the purpose, from the inside, in a somewhat slanting direction, and the points of the teeth are inserted in these holes through the whole of the belt, so as to project at the opposite side to that at which they are inserted. The plate cover or clasp proper is then slipped over the projecting teeth, of course tying them securely fast, and making the complete buckle. With very wide belts several such buckles are applied. Such a joint is clearly as applicable to india rubber, gutta-percha, or woollen belts, as to those of leather."—*The Engineer*, *Jan.* 27, 1870, *p.* 56.

Belts for Rolling Mills.—"Nearly all rolling mills in Pittsburgh are driven with belts, from 20 inches in breadth upwards; something like the proportions may be guessed at from the following: One mill has a pulley 26 feet diameter, 66-inch face, with two 32-inch belts running to a pulley overhead, about 8 feet diameter. Another is 25 feet diameter, 45-inch face. Engines with such wheels and belts are being built every day, giving great satisfaction.

"The question of driving rolling mills with belts might be dwelt upon, but its advantages must be apparent to any practical man."—*The Engineer*, *March* 4, 1871, *p.* 213—*Englishman.*

Dressing for Leather Belts.—"One part of beef kidney tallow and two parts of castor oil, well mixed and applied warm.

"It will be well to moisten the belt before applying it. No rats or other vermin will touch a belt after one application of the oil.

It makes the belt soft, and has sufficient gum in it to give a good adhesive surface to hold well without being sticky.

"A belt with a given tension will drive 34 per cent. more with the hair side to the pulley than the flesh side."

F. W. BACON, N. Y.

An engineer of considerable practical experience with machinery replies to queries thus:

Rule for horse-power of a belt—

$$\frac{\text{H. P.} \times 26000}{\text{V} \times \text{C} \times 6} = \text{W}.$$

In which H. P. = horse-power.

V = velocity of belt in feet.

C = circumferential contact with smaller pulley in feet.

W = width of belt in inches.

"Single belts have given us the best satisfaction, taking less power to drive them, and adhering to the pulleys much better, and do not crack in bending.

"The area of belt contact determines its driving power.

"For fastening the ends we consider hooks the best for small belts. For large belts we use hooks, with the addition of a piece of leather rivetted over the lap.

"The best composition for preserving belts and giving them adhesion, is oil with a small quantity of rosin in it.

"Thin belts are better than thick ones.

"The convexity of pulleys should be the least possible, not over $\frac{1}{8}$ inch to the foot of breadth."

Another engineer gives the following:

"To find the number of horse-power which a belt will transmit, multiply the number of square inches of belt contact with the pnlley by the velocity of the belt in feet per minute, and divide the product by 64000."

A skilful machinist, of much experience with experimental machinery, says:

"In answer to question 8, the best method of joining belts that I know of is by the ordinary lacing. The holes therefor should be punched about three-quarters of an inch apart, or as near that as the equal division across the belt will allow, and for wide belts two rows of holes should be punched, in a zigzag direction, commencing with the lace in the middle of the belt, and lacing singly to each edge, returning to the centre and securing the ends, crossing the lace on the outside of belt.

"I have found this plan preferable to the one generally adopted, that is, of lacing double at once across the belt finishing at one edge, the objection to which is in the loosening of the ends of the lace and yielding of the joint at one edge, which will crook the belt and render it liable to lateral running, off the pulleys, against flanges, into gear perhaps, and may permanently stretch the belt so unevenly as to make straight running again matter of impossibility.

(To be continued.)

THE PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Joseph M. Wilson, C. E.

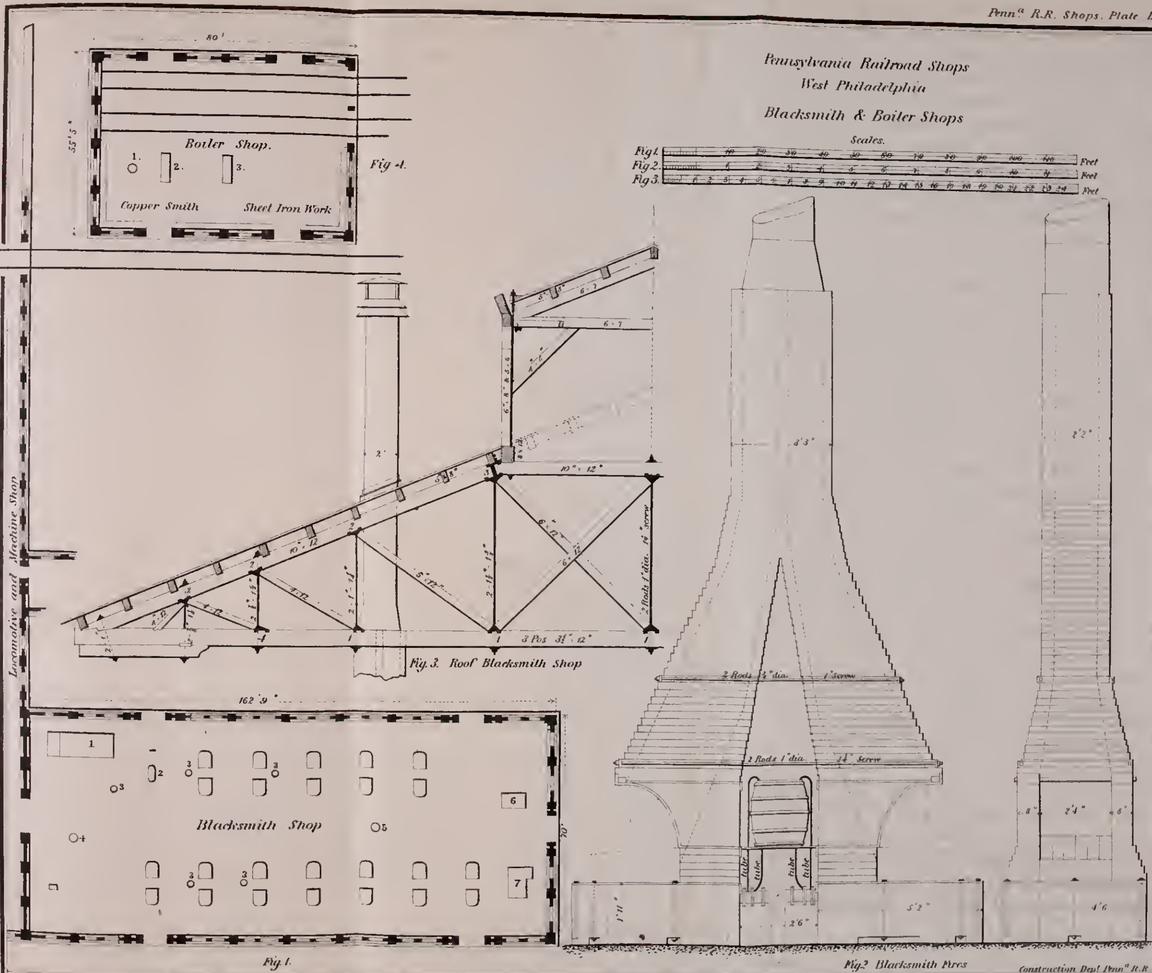
[P. A. Engineer, Construction Department, Pennsylvania Railroad.]

(Continued from Vol. LXI. p. 102.)

West Blacksmith Shop.—This building, designated No. 3 on Plate I., is intended to accommodate all smith work at these shops connected with repairs in the motive power department, and hence its close vicinity to the locomotive and machine shop. Its outside dimensions as seen by the plan, Fig. 1, Plate IX., are 162 feet 9 inches by 70 feet, affording an inside floor area of 10,626 square feet. It is unnecessary to go into any details respecting the construction of the walls of the building, the doors, windows, &c., as it would be merely repeating what has been mentioned previously for the locomotive and machine shop. The roof truss, however, is different in some respects. The principals are placed 16 feet 4 inches apart, centre to centre, being framed as shown in Fig. 3, Plate IX. The number and size of the different timbers, and the diameters of the vertical tie rods are given on the Plate. The angle blocks are numbered, the numbers as marked on the elevation of the roof, corresponding to those given in Fig. 3, Plate VI. The purlins are 5 by 8 inches section placed three feet apart, and the ventilator is provided at the sides with open slats instead of glazed sash, so as to furnish free egress for any smoke that may accumulate in the upper part of the building, and afford thorough ventilation. As regards the details of connection of the different parts of the roof, the roof covering, drainage, &c., they are the same as given for the locomotive and machine shop.

The building contains twelve double brick forge fires, of which Fig. 2, Plate IX, shows the construction. Each hearth is 5 feet 2 inches long by 4 feet 6 inches wide and 1 foot 11 inches high, having a curved front. The top is protected around the edge by a flat wrought plate $\frac{5}{8}$ by 4 inches section, well secured by anchor bolts to the brickwork. Five courses of brick are laid on the hearth to form the back, and on these the brackets for supporting the hood to the fire, are set. These are $\frac{3}{4}$ by 8 inches section, curved as shown. At the top they are anchored back into the brickwork by wrought plates $\frac{5}{8}$ by 8 inches, and the brackets of a pair are connected in front by a tie bar 1 by 3 inches section. The hood is then carried up in brickwork, the opening of the flue being as shown by dotted lines on the Plate. The back for the fire is of fire brick. The flues are built on an incline, approaching each other until they meet some distance above, forming a figure like an inverted V. They are then carried up vertically to a height of 20 feet above the ground, where the brickwork stops and both flues are run into a circular sheet iron stack, 2 feet in diameter and 21 feet high, surmounted by a ventilating cap. Wrought plates and tie rods are used at two places below where the chimneys meet, to bind them together and counteract any thrust which may result from their inclination. The blast is driven by a No. 8 Dimpfel Patent Blower. The blast pipes are laid in two lines, one under each row of fires, both lines coming together before reaching the blower. They are of cast iron, with planed flange connections, and vary in internal diameter from 10 inches at the blower to 4 inches at the farthest extremity. From the main pipe a 4-inch double branch pipe goes off vertically under each pair of forges, throwing a blast into each fire. Each branch has a valve to properly regulate the amount of blast, and terminates in a $2\frac{1}{2}$-inch copper pipe, which passes into the tuyere. The tuyere is of cast iron, made hollow, and kept cool by a circulation of water through it, being connected by two lead tubes with the water tank shown in the Plate between the fires and above them.

In addition to the forge fires described, this shop also contains the following: No. 1 is a heating furnace, built by Matthews and Moore, and very useful for working up scrap. No. 2 is an open forge, for heating large forgings. Nos. 3 are cranes, the largest not lifting over two tons. No. 4 is a Thwaites & Carbutt steam hammer, of 1500 pounds weight, and No. 5 is a hammer by the same


Pennsylvania Railroad Shops
West Philadelphia
Blacksmith & Boiler Shops
Scales.
Fig. 1.
Fig. 2.
Fig. 3.
Feet
Boiler Shop.
Copper Smith
Sheet Iron Work
Fig. 4.
80'
55' 5"
Locomotive and Machine Shop
Fig. 3. Roof Blacksmith Shop
3 Pcs 3½" 12"
10" × 12"
2 Rods 1" dia. 1½" screw
Blacksmith Shop
162' 9"
70'
Fig. 1.
2 Rods ¾" dia. 1" screw
2 Rods 1" dia. 1¼" screw
tube
3' 3"
2' 2"
2' 4"
5' 2"
4' 6"
2' 6"
Fig. 2 Blacksmith Fires
Construction Dep! Penn^a R.R.

makers, of 800 pounds weight. No. 6 is a flanging forge and furnace, constructed on Nixon's Patent of June, 1868. The forge is built of iron, the bottom being double, and kept cool by a circulation of water through it. The holes for blast are distributed over the bottom, 4 inches apart, and a fire can either be built over the whole forge, or, by temporarily stopping as many of the blast holes as necessary with small rivets, a smaller fire can be used. On the floor in the space around this forge are placed the various forms for shaping sheets of boiler plate into the different parts of the boiler and fire-box of the locomotive. No. 7 is a case-hardening furnace, and a reverberatory furnace for springs.

Boiler Shop.—This shop, marked No. 4 on Plate I, is a brick building, constructed in the same style as those previously described, and has an inside floor area of 3914 square feet. It has two tracks, one for boilers and the other for tanks, and contains the necessary accommodations for copper and sheet iron work, and the following machinery (see Fig. 4, Plate IX):

No. 1. An open fire, for use of copper and tinsmith.

No. 2. Punch and shears combined; clear, 20 inches. William Sellers & Co., makers.

No. 3. Set of hand rolls, 78 inches long, 9 inches diameter. Wm. Sellers & Co., makers.

Also, a drill, not marked in the Plate.

(To be continued.)

ON A SHIP CHANNEL ACROSS CAPE COD.

By Jos. P. Frizell, C. E.

(Continued from Vol. LXI., page 391.)

The River Clyde,* from the Port of Glasgow to the Sea, offers one of the most remarkable instances of the employment of tidal currents in deepening a channel. In the year 1755 John Smeaton examined and reported upon the Clyde with a view to the improvement of its navigation. His report speaks of it as a very irregular stream varying in width from 400 to 1400 feet. The depth in the vicinity of Glasgow at the period of high tide was but 3 feet 6

* The following historical sketch is from the Life of Thomas Telford, pages 492, 501.

inches, allowing only the highest barges to approach the city. The prospect of deepening the channel of the stream appeared so unpromising to him, that he recommended the construction of a weir and lock, at a point below the city into a basin. He hoped by this means to enable vessels of 6 feet draft to reach the city. This recommendation was not adopted.

In 1768, in accordance with the advice of J. Golborne, it was decided to attempt the improvement of the depth by means of wing dams projecting from the shore, their purpose being to quicken the current by contracting it. This method was first put in practice in 1772 at Dumburk Ford. The channel was contracted by means of wing dams to a width of 300 feet. The results exceeded the expectations of the projectors, and the method was applied to the entire stream so far as it required deepening. In 1807 Rennie advised the construction of parallel dams omitting the heads of the wing dams, which recommendation was adopted, and works executed in accordance therewith, wherever the wing dams were not sufficiently close to one another to have the desired effect upon the current. By a report of John Clark, in November, 1824, it appears that vessels of 11 feet draft could enter the Port of Glasgow without difficulty at high tide. About this time a permanent force of dredges was put in operation at localities where from the refractory character of the bottom or other circumstances, the method of quickening the current was not effective. By a report of James Walker, in 1836, it appears that points in the vicinity of Glasgow which formerly had a depth of 16 inches now had a depth of 7 or 8 feet at low tide. That the tide at Glasgow which formerly was hardly observable, now amounted to 7 or 8 feet at spring tides, and 4 feet at neaps.

*At present the Port of Glasgow is accessible to vessels drawing 17½ feet, and one significant fact is to be noted in this connection, viz: that the entire cost of these improvements up to a recent date extending over a channel some 20 miles in length and embracing nearly a century of time, including much fruitlessly spent upon the wing dams, and also the quays at Glasgow necessary for the accommodation of its enormous trade, has amounted to a less sum than was estimated for the C. C. Ship Canal†. One of the ablest of modern hydraulic writers‡ says: "The remarkable increase of

* Lippincott's Gazetter, art. Glasgow.

† Lippincott's Gazetter, art. Glasgow.

‡ G. Hagen, Wasserbaukunst, Zweiter Theil. Die Ströme, Vol. II., page 247.

depth in the Clyde is due solely to the strengthening of the tidal current. By this means is the volume of water conveyed alternately, in opposite directions, greatly increased, and the diminutive creek converted into a powerful stream."

When we see, on the one hand, a community laboring for a century to improve a navigable channel, persistently employing tidal currents as the chief agent therein, expending great sums in works designed to strengthen and give efficacy to these currents; and, on the other hand, find people recommending the expenditure of vast sums in works designed to exclude the tides from a navigable channel, we are led to think that one or other of these methods must rest upon an unsound principle. If we are to judge from results that method is not the one upon the Clyde.

The mouths or entrances of this channel would be substantially in the condition of the estuaries of tidal rivers, and would in some degree be liable to the difficulties that belong to such estuaries. One of these difficulties is that the current being brought to rest, or nearly to rest, upon entering the sea, deposits the material which it has abraded from the bottom and sides of its channel, creating the bars and shoals so common at the mouths of rivers. There is, of course, no reason to apprehend that this action would take place upon anything like the scale of magnitude observable in great rivers. From the short length of the channel comparatively little material would be taken up by the current. To whatever extent it did occur, however, it would require to be dealt with by the methods usually employed in such cases, among which it must be conceded that schemes involving the use of locks have met with but slight favor during the present century. The methods that have met with the most signal success have consisted in increasing the abrasive action of the current, sometime narrowing the channel and throwing the current in greater volume and velocity upon the bars by piers, sometimes by harrowing or raking the bar when the effluent current is strongest.

Messrs. Humphreys and Abbott* say in reference to the mouths of the Mississippi: "The develepment of laws which govern the formation of the bars has removed all uncertainty as to the principles which shall guide an attempt to deepen the channels over them. The erosive or excavating power of the current must be increased relatively to the depositing action. This may be done either by

* Report on the Physics and Hydraulics of the Miss. River, p. 255.

increasing the absolute velocity of the current over the bar, or by artificially aiding its action. To the first class of works belong jetties and the closing of lateral outlets. To the latter. stirring up the bottom by suitable machinery, blasting, dragging the material seaward, and dredging by buckets. These plans are all correct in theory, and the selection from them should be governed by economical considerations."

Movable jetties,* so constructed as to admit of being floated to any required position and removed on the approach of storms, have been used in some French harbors, particularly in the harbor of Dunkirk with very favorable results.

In 1858, a technical congress† assembled in Paris, composed of delegates from seven of the European states, to decide upon the best means of improving the mouths of the Danube. Two projects were brought before the convention. The first proposed to cut a ship canal from one of the main passes of the Delta, closing its upper entrance by a lock, and prolonging it by stone embankments until sufficient depth of water was reached. The second proposed to prolong the channel of the pass selected for improvement by parallel piers, directing the current with greater force upon the shoals. The first scheme, it will be noticed, proceeded upon the principle adopted by the advisory council upon the Cape Cod Ship Canal, the principle of excluding the current. The second upon the principle of giving full play to the current and taking all possible advantage of its abrasive action. Long journeys were performed by members of the convention in order to satisfy themselves by an inspection of existing works, as to which principle was best entitled to preference. The second method was adopted. ‡The works were commenced under the direction of Sir John Hartley, in 1858, at the Sulina mouth of the Danube, which at that time was not navigable for vessels drawing over 9 feet of water. Two piers were constructed, one 3,000 the other 4,631 feet long at a cost of $50 per linear foot. In 1861, this channel was navigable for vessels drawing 16 feet.

* Hagen, See-ufer und Hafen-Bau, Vol. III., page 80. Also Belidor. Architecture Hydraulique, Liv. III., chap. iii., sect. 3.

† Rapport de la Commission Technique Internationale convoque à Paris pour l'examen des questions relatives à l'amelioration des bouchs du Danube. Paris, 1858.

‡ Chief Engineer and Architect's Journal, 1862, page 115.

We all remember how fruitless were the attempts made to close the port of Charleston during the rebellion by sinking vessels loaded with stone in the principal channels. The current was checked in its usual channels only to be thrown with increased vigor upon the adjacent ground, and soon excavated new channels as deep as the former. A shallow depth, in soft material, is incompatible with a strong current.

The easterly entrance to this channel would be exposed to another cause of obstruction, viz: material borne along the shore by the action of the waves. This is a danger to which the entrances of many harbors are exposed, and would not, in this case, require any deviation from the methods ordinarily employed. The remedy lies not in the construction of locks or artificial harbors, but in giving a proper direction to the effluent current, and, perhaps, in the construction of groins along the beach to intercept the supply of travelling material.*

The Suez Canal would seem to deserve mention here, being constructed without locks. The precedent, however, is not conclusive, as the mean difference of level between the basins connected by it is only two feet. The Red Sea † is liable to fluctuations of 6·5 feet at spring tides, and 10 feet through the action of high winds. These heads, however, distribute themselves through a long stretch of the canal, and do not create currents comparable to those that might be expected in the C. C. Channel. These currents, however, are regarded as a very favorable circumstance with reference to the preservation of a sufficient depth at the Suez entrance, and the almost total lack of any such scouring agency at the northerly entrance has, in all discussions relative to this enterprise, been regarded as its most discouraging feature. This was one of Robert Stephenson's chief objections to the work, and this is what necessitates the immense piers, now over a mile in length and proposed to be extended to a length of four miles, at this extremity of the canal.

It may be said that the difference in cost between a closed canal and a free channel is apparent rather than real, since the artificial harbor, which forms the chief item in the cost of the former, might be dispensed with. I answer that an artificial harbor is the indis-

* As an example of the usual practice in such cases, see Discussions and Reports of Engineers upon the Harbor of Harurch Eng. Brit. Sess. Papers, 1861, v. 38, 1862, v. 34.

† Hagen, Wasserbaukunst See-ufer und Hafen-Bau. Vol. IV., page 75.

pensable accompaniment of a closed canal. In no other way can an entrance from an exposed coast be kept open, unless it is traversed by powerful currents. The approaches to a lock, on a sandy coast exposed to violent waves would fill up during a single storm. Dredges, from the nature of the case, cannot be effectively employed in such exposed localities, and no sluicing consistent with the maintenance of the canal surface at the level of high tide would be effective against such titanic agencies. The fatal decision to employ locks carries with it the inevitable necessity for a closed harbor. Give, however, the freest and fullest admission to the tides, and this necessity vanishes. So far as a harbor is necessary for the shelter of vessels, that can be obtained by running into the channel. So far as it is necessary to prevent the shoaling of the approaches, you establish a remedial force equal in activity to the destructive power of the waves, and which only needs suitable direction and control to enable it effectively to guard the entrance.

The learned and eminent gentlemen composing the advisory council upon the C. C. Ship Canal, in a former report, addressed to the city government of Boston * dwelt with great force and clearness upon the efficiency of tidal currents in maintaining a suitable depth in the channels of the harbor. Had there existed a natural channel across Cape Cod, and had they been desired to suggest suitable methods of improving and deepening it, I cannot think that they would so far have defied the most instructive precedents of modern engineering as to advise the exclusion of the tides. The problem, however, being the creation of an artificial channel instead of the improvement of a natural one, they were led by analogy rather than by investigation to recommend the use of locks.

The preceding hasty and imperfect sketch of this subject appears to me to warrant the following conclusions:

1. That the two modes of executing this work, the one by a closed canal, the other by a free channel, are founded respectively upon two radically diverse principles, of which the latter has received, by far, the more extended and successful application in the practice of modern engineers.

2. That while a free channel might not permanently maintain, in all parts, a sufficient depth, if abandoned entirely to the operation of natural agencies, yet, by establishing a suitable working force under judicious direction, to control the current, to protect the

* Boston City Doc., No. 12, 1861.

shores where abrasion was too rapid, to quicken the current where deposits occurred, to remove such deposits by dredging where less expensive means availed not, to repress, in a word, the mischievous and aid the conservative tendencies of the current—a suitable depth might, with a moderate annual expenditure, be maintained.

3. That with a free channel, no harbor, properly so-called, would be necessary.

Allowing two million dollars for excavation, one million for piers, groins, &c., and the interest of two millions for maintenance, the cost of the free channel would still be not more than half that of a closed canal with its necessary appurtenances.

THE KEOKUK AND HAMILTON BRIDGE OVER THE MISSISSIPPI RIVER AT KEOKUK, IOWA.

Statement of the Public Test of the Structure.

This bridge was tested May 18th, 1871, for Mr. J. Edgar Thomson, President of the Pennsylvania R. R. Co. The tests were made under the direction of Mr. Henry Pettit, Civil Engineer Construction Department Pennsylvania R. R., and all facilities for making them satifactory were kindly furnished by Mr. Geo. S. Smith, the Engineer of the Bridge, resident at Keokuk, who has had charge of the work at the bridge site from its commencement to its successful completion.

The designs for the superstructure were furnished by Mr. J. H. Linville, C. E., the drawings being carefully worked up under the direction of Mr. M. Benner at Pittsburgh. The superstructure was made and erected by the Keystone Bridge Co., of Pittsburgh.

Commencing at the west or Keokuk end of the bridge, the spans are located as follows: Pivot span, total length of one truss, centre to centre of end posts, 376′ 5″; opening under each arm of 160 feet measured on the square; 2 spans, 253′ 6″; 8 spans varying in length from 148′ 4$\frac{3}{16}$″ to 161′ 7″; total length backwall to backwall on bridge seats, 2,192 feet. It is a through bridge built on a skew of 17° 15′, with a distance between the two trusses of 21′ 6″. It carries a single line of railway track and two tramways for local traffic, the track being placed in the centre between the tramways. On each side of the bridge, outside of the trusses, are foot-

walks 5 feet wide protected by light and substantial iron lattice railings.

When making the tests the level and rod were in charge of Mr. E. H. Worrall, Engineer of the Section Work, and Major A. H. Burnham, U. S. A., Engineer in local charge of the Des Moines Rapids Improvements of the Mississippi River near Keokuk.

The load used in making the tests was a train made up of five engines from the Des Moines Valley Railway, with their tanks and boxes full.

The following table shows the composition of this train.

Engines.	Total Length Engine and Tender.	Weight of Tender.	Weight of Engine.	Total Weight.
No. 1	39 feet.	16 tons.	26 tons.	44 tons.
19	41′ 7″	20 "	31½ "	51½ "
22	42′ 5″	20 "	31½ "	51½ "
20	41′ 7″	20 "	31½ "	51½ "
3	40′ 5″	18 "	27 "	45 "
Totals	205′ 0″			243½ tons.

This load was placed so as to cover one-quarter of the span, when the deflections of the span were taken at the centre and quarter distances. The span was then loaded one-half of its length, then three quarters, and finally its entire length. The deflections being taken each time at the same three points. Afterwards the permanent set was observed. All the lengths of spans given are the distances from centre to centre of the end posts.

Pivot span (the largest yet constructed.)

Total length of one truss.. 376 ft. 5 inches.
Arched upper chord. Depth of truss over drum...... 35 ft.
" " at ends......... 27 ft. 9 inches.

Load of 95·5 tons on the east half of the east arm = 1·07 tons per foot lineal.

East arm of span.

Deflection of the east half .... $\frac{1}{8}$ inches.
Deflection at the centre... $\frac{15}{32}$ "
Deflection of the west half.. $\frac{3}{32}$ "

West arm of span.

Deflection of the east half.. $\frac{3}{32}$ inches.
Rise of the centre.. $\frac{3}{32}$ "
Rise of the west half.. $\frac{3}{64}$ "

Load of 178·5 tons, covering entirely the east arm = 1 ton per foot lineal.

East arm of span.

Deflection of the east half.. $\frac{23}{32}$ inch.
Deflection at the centre.. $\frac{15}{16}$ "
Deflection of the west half.. $\frac{23}{32}$ "

West arm of span.

Rise of the east half.. $\frac{1}{32}$ inch.
Rise at the centre.. $\frac{1}{8}$ "
Rise of the west half.. $\frac{3}{65}$ "

Strain of compression at centre of upper chord of east arm...6752 lbs. per sq. in.
Strain of tension at centre of lower chord of east arm.........7063 " " "

Load of 103 tons on east arm and 96·5 tons on the west arm = ·56 tons per foot lineal.

East arm—

Deflection at the centre.. $\frac{23}{32}$ inch.

West arm—

Deflection at the centre.. $\frac{15}{32}$ inch.

Permanent set after all load was removed.

East arm—

East half.. $\frac{1}{80}$ inch.
Centre.. $\frac{1}{32}$ "
West half (next the drum)... $\frac{1}{16}$ "

West arm—

East half (next the drum)... $\frac{5}{32}$ inch.
Centre.. $\frac{1}{80}$ "
West half.. $\frac{1}{32}$ "

Time of turning the pivot the entire opening of $72\frac{3}{4}°$.

With the engine... 2 minutes.
With six men.. 2 minutes 30 seconds.

Span No. 3.

Length 253′ 6″. Height of truss 27 feet.

Ratio of height to length = 1 to 9·388. Load of 68 tons on the east quarter = 1·07 tons per foot lineal.

Deflection of the east half.. $\frac{5}{32}$ inch.
Deflection at the centre.. $\frac{1}{8}$ "
Deflection of the west half.. $\frac{1}{32}$ "

Load of 147 tons on the east half of span = 1·16 tons per foot lineal.

Deflection of the east half	$\frac{19}{32}$ inch.
Deflection at the centre	$\frac{25}{32}$ "
Deflection of the west half	$\frac{13}{32}$ "

Load of 198·5 tons on the east three-quarters of span = 1·04 tons per foot lineal.

Deflection of the east half	$\frac{31}{32}$ inch.
Deflection at the centre	$1\frac{3}{8}$ "
Deflection at the west half	$\frac{29}{32}$ "

Spread of lower chord measured at the roller box = $\frac{3}{16}''$.

Load over the entire span of 243·5 tons = ·96 tons per foot lineal.

Deflection of the east half	$1\frac{5}{32}$ inches.
Deflection at the centre	$1\frac{11}{16}$ "
Deflection of the west half	$1\frac{1}{4}$ "

Spread of the lower chord measured at the roller box $\frac{1}{4}''$.

Strain at centre of upper chord, compression = 8962 lbs. per square inch.

Strain at centre of lower chord, tension = 9251 lbs. per square inch.

Span No. 2.

Length 253′ 6″. Height of truss, 27 feet.

Load of 243·5 tons over the centre span = ·96 tons per foot lineal.

Deflection at the centre of span = $1\frac{3}{4}$ inches.

Permanent set after load was removed = $\frac{3}{64}$ inches.

Span No. 4.

Length 159 feet $9\frac{1}{8}$ inches. Height of truss 21 feet.

Ratio of height to length 1 to 7·6·

Load of 44 tons on the east quarter = 1·1 tons per foot lineal.

Deflection of east half	$\frac{9}{32}$ inch.
Deflection at the centre	$\frac{5}{16}$ "
Deflection of the west half	$\frac{19}{32}$ "

Load of 95·5 tons on the east half = 1·19 tons per foot lineal.

Deflection of the east half	$\frac{7}{16}$ inch.
Deflection at the centre	$\frac{23}{32}$ "
Deflection of the west half	$\frac{1}{8}$ "

Load of 147 tons on the east three-quarters of span = 1·22 tons per foot lineal.

Deflection of the east half	$\frac{5}{8}$ inch.
Deflection at the centre	1 "
Deflection of the west half	$1\frac{3}{16}$ "

Lood of 153 tons over the entire span = ·905 tons per foot lineal.

Deflection of the east half	$\frac{25}{32}$ inches.
Deflection at the centre	$1\frac{5}{32}$ "
Deflection of the west half	$1\frac{5}{16}$ "

Permanent set after load was removed. At the centre of span = $\frac{1}{4}$ inch.

RAILROAD BRIDGE OVER THE CUMBERLAND RIVER AT NASHVILLE, TENN.

By F. W. Vaughan, C. E.

This bridge carries the traffic of the Louisville and Nashville, and Edgefield and Kentucky Railroads over the Cumberland River at Nashville, Tennessee, and as a link in the chain of direct railroad connection with the South, is second in commercial importance to no bridge south of the Ohio River; to the engineer it is of particular interest as the first example of the Iron Triangular Truss constructed in this country.

Before giving a detailed description of the existing superstructure, a few facts concerning the sub-structure, as well as the preceding superstructures will be of interest.

The masonry was built in 1858–9, and on it was erected a McCallum superstructure, the successful construction and operation of which was at the time considered a great triumph in bridge building. This structure did good service till February, 1862, when, upon the approach of the Federal troops, the Confederates loaded it with guns and other munitions of war, and destroyed it by fire; the slight damage thus done to the masonry was repaired and a superstructure promptly erected on the Howe plan by the U. S. Government, the railroad Company subsequently paying for the same.

This structure sustained the heavy traffic incident to the war satisfactorily, till the fall of 1866, when it began to show decay and weakness; as it was impracticable to erect another superstructure before the following season, iron clamps were put on the lower chords, and the spans otherwise strengthened, so that they did service till replaced by the existing structure in the summer of 1867.

Arrangement of Spans.—The total length of bridge is 700 feet, and is divided into two fixed spans of 210 feet each from centre to centre of piers, and a draw span 280 feet long over all, with clear openings of 120 feet, the draw being between the fixed spans. (See general view, Fig. 1, Plate I.) The base of rail is about 80 feet above the rock bed of river, and the clear space above high water is 7 feet.

Masonry.—This is of limestone laid in cement, and consists of five piers, (including two rest piers for draw at right angles to line

of bridge), and two abutments; the aggregate quantity is 6,300 cubic yards. The Western abutment and all of the piers have for their foundations the solid rock, while the Eastern abutment rests on an artificial foundation of concrete over-piling. The piers were put in by coffer dams without trouble, the minimum summer depth of water being only twelve feet.

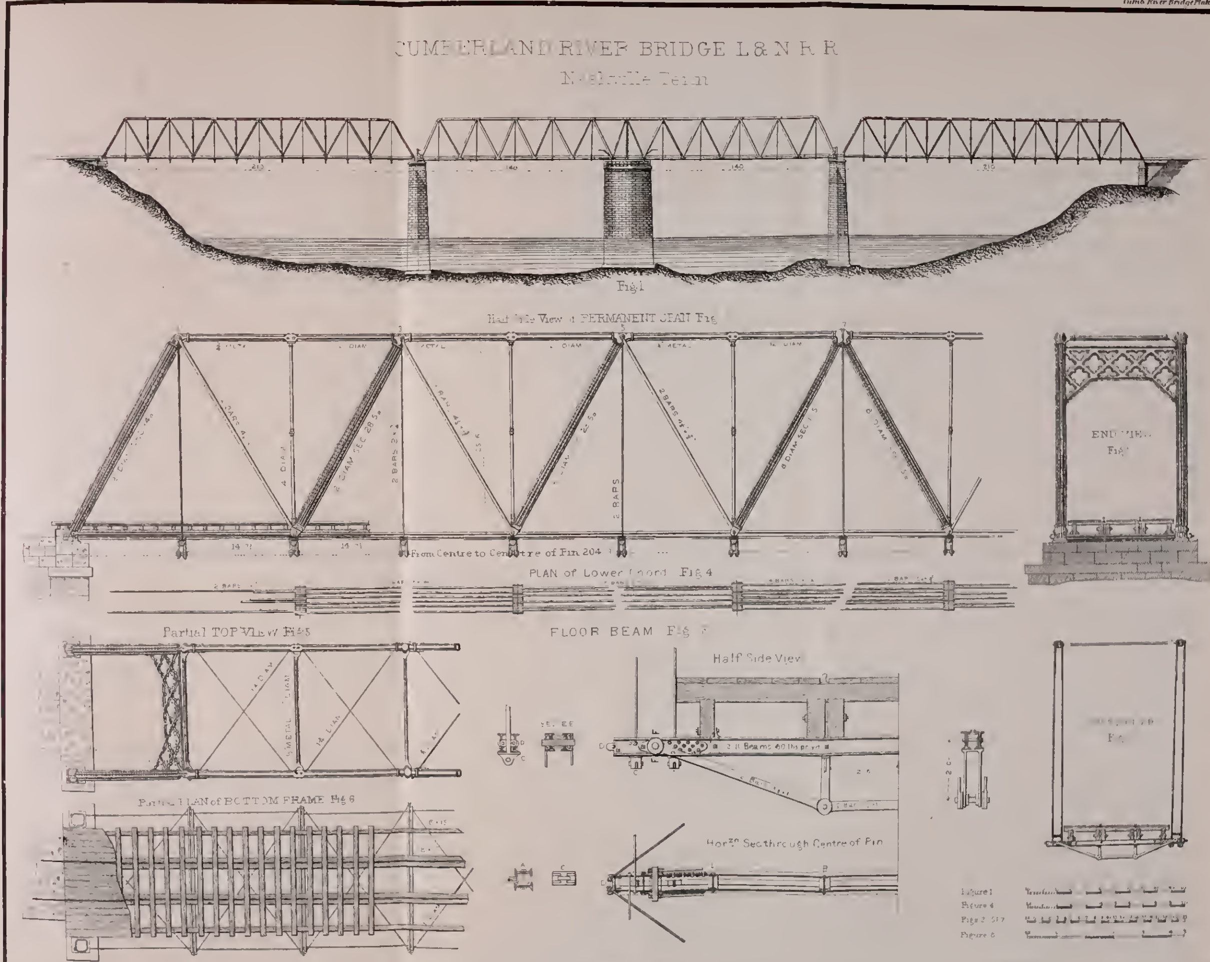
The regular piers are 10′×25′ under the coping, and have a batter of one-half inch per foot. The rest piers are 3′×25′ under the coping, and are strengthened by massive starlings. The round pier is 30 feet diameter, and has a slight batter.

Existing Superstructure.—This consists, as already stated, of two fixed spans, and a draw; it is on the triangular plan, and entirely of iron. The iron work was commenced in the spring and the bridge raised during the season of low water in the summer of 1867. The operation of raising was attended with considerable difficulty, on account of the position of the bridge, forming as it were a part of the yard in which trains are made up at Nashville. The workmen not only had to guard against the delay of regular trains (of which there were many), but offer as little obstruction to the regular switching of the yard as possible, very little of which could be done without running on or over the bridge. The removal of the old Howe trusses, and the erection of the present ones, was accomplished without delaying any of the regular trains. The draw was raised in the line of the bridge, there being no boats with which the trestle would interfere at this season.

The work for the fixed spans was done in the shops of the Louisville and Nashville Railroad at Louisville, and for the draw by the Louisville Bridge and Iron Company.

Fixed Spans.—These are 210 feet from centre to centre of piers. The trusses are placed 16′ 6″ apart between centres, have a depth of 25′ 6″, and a length of 204′ 9′ from pier to pier. Figure 2 Plate I is a side view of half one of these spans, Fig. 3 an end view, Fig. 4 plan of lower chord, Fig. 5 a partial view of top frame, and Fig. 6 a partial view of bottom frame.

The top chords are cast iron tubes, octagonal on the outside and circular on the inside, with a uniform external diameter of 12 inches; the thickness of metal varies in the different panels, being reduced in proportion to the strain from middle to end of span. The cords are cast in sections, (with brace seats attached), the length of the long panel (29′ 3″), joined by tenons and sockets,



CUMBERLAND RIVER BRIDGE L & N R R
Nashville Tenn
Fig 1
Half Side View of PERMANENT SPAN Fig
From Centre to Centre of Pin 204
PLAN of Lower Chord Fig 4
END VIEW Fig
Partial TOP VIEW Fig 5
FLOOR BEAM Fig 7
Half Side View
Partial PLAN of BOTTOM FRAME Fig 6
Hor.l Sec through Centre of Pin

(turned and bored to fit), the abutting faces and brace seats are carefully faced off, and the pin holes drilled to fit the pins. The quality of metal in each casting was tested by pouring from the ladle containing the mixture for this casting, two test bars five feet long, and one inch square, each when placed upon knife edges four feet six inches apart was required to sustain 525 lbs. applied at its centre, this degree of strength having been shown by various experiments to indicate a first-class mixture of cast iron ; two bars were always made to ensure a test, it sometimes happening that one would have a flaw. One sound test-bar breaking with less than the proscribed weight, would ensure the rejection of the casting from the same ladle. This, however, did not occur—the bars breaking on an average with 570 lbs., and one with as high as 650 pounds.

Mr. Fairbairn, in his work on cast and wrought iron, page 72, records the results of testing forty-one different kinds of English irons, in bars the same as here used. The highest test thus obtained was 567 lbs., and the lowest 353 lbs. Before finishing these chord pieces small holes were drilled at the two points where the core was most likely to rise, and the metal measured to ascertain if any inequality of thickness existed, they were also carefully examined and hammered to detect "cold shuts," "air blows," or other defects. The struts connecting the top chords and forming part of the top system of lateral bracing, the brace shoes, pier bearings, floor beam posts, &c., are also of cast iron, and of the same quality as the chords.

The braces are wrought iron Phœnix columns, sections of which are shown by Fig. 2. They were well painted on the inside before erection.

The vertical posts are wrought iron tubes $4\frac{1}{2}''$ diameter each post is spliced at its middle by a cast iron swivel with a right and left hand thread, which also serves as an adjustment for the length of the post.

The wrought iron for the lower chords, ties, suspension bars, diagonal rods, pins, &c., is of the best quality, having an ultimate strength of 60,000 lbs. per square inch. The heads are welded to the bars, and the pin holes drilled to closely fit the pins, which are carefully turned. The bars were all tested with a strain of 20,000 lbs. per square inch, (nearly twice the maximum working strain). The spans rest at the piers on planed cast iron plates, on which they slide when effected by changes of temperature. Fig. 7 shows the arrangement of roadway supported by transverse iron floor beams, shown in detail by Figures 8 and 9.

(To be continued.)

Mechanics, Physics, and Chemistry.

PHOTOGRAPHING THE CORONA.

By Prof. Edward C. Pickering.

The difficulty in photographing the corona visible around the sun during a total eclipse, is mainly due to its small actinic power. To remedy this we must increase the light in our camera as much as possible, and therefore when attached to Prof. Morton's Eclipse Party, in August, 1869, I proposed that a common portrait camera should be used. As with such an instrument we can obtain an impression of objects in a comparatively dark room in a few seconds, it seemed probable that in two or three minutes so bright a body as the corona would produce a very distinct impression, even of its more remote portions. We found in Mt. Pleasant where we were stationed, two photographers, Messrs. Hoover Bros., who undertook to give this plan a trial, and as a result they obtained a photograph, which is represented in the accompanying figure to double its original size. I believe the exposure lasted during nearly the whole period of totality, the apparent motion of the sun being avoided by following it with the camera. The aperture of the lens being much greater compared with its focal length than that of any telescope, so much light is concentrated that an impression of a large part of the corona is obtained, giving one of the best photographs of this body yet taken.

A comparison with the view taken by Mr. Whipple in Shelbyville shows many points of resemblance, and greatly strengthens any conclusions based on either. It also proves that the structure common to both is solar, or at least not due to any local irregularities in our own atmosphere. The indentation in the moon's limb marks the position of the large protuberance then visible, and we readily perceive the bases of the five points or streamers which were noticed at the same time. The line N. S. gives the direction of the sun's polar axis and shows the increased height of the corona at its equator, and the corresponding diminution at its poles. The experiment is so easily tried by any photographer on the line of totality as to encourage the hope that in future eclipses, views may be taken from a great many points with the largest portrait cameras, and thus eliminating all local effects, show with certainty how much of the corona is really solar.

Massachusetts Institution of Technology, May 15th, 1871.

PENNSYLVANIA'S ANCIENT SEA.

Lecture delivered before the Franklin Institute, Thursday evening, Jan. 5, 1871.

By Prof. Leeds.

In a preceding lecture, upon Pennsylvania's Foundation Stones, I have sketched out the anatomy of the North American Continent. We have seen that there is a broad area, which includes almost the whole of New England, northern New Jersey, south-eastern Pennsylvania, the middle of Maryland and Virginia, and stretches thence southward to the centre of Georgia and Alabama, that is made up of gneissoid rocks. It has served, in the structural growth of the continent, as a vertebral column, a backbone to which the later formations have attached themselves in the process of development of an organic whole, such as the continent presents itself to us at the present day. I say organic, because no other word appears adequately to express the mutual dependence and co-operation of its various parts. For has it not a most highly complicated fluid circulation? Are not vast bodies of water daily lifted from the ocean to its table lands and mountain tops, and then poured through a million capillaries and arteries, so as to refresh the plains with gladness and fertility? Its endless modifications of surface, its countless valleys and hills divide the trade winds into myriad currents and counter-currents, and originate an ærial circulation so perfect that miasm and pestilence are well nigh unknown. Here are boundless stores of coal and iron, there salt and oil, copper is found in a third place, in such huge masses that the miners are at a loss how to work it, while the slopes of the Sierra Nevada have revealed at last the long sought for El Dorado. No part of the continent is complete in itself, but taken in conjunction with all the rest, it makes a geological unit.

From this backbone there extend two arms, one lifted to the north-east and stretching from northern New York to the coast of Labrador, the other much longer, reaching to the shores of the Arctic Ocean.

This backbone and these two arms, as we have seen previously, have survived from a world which perished beneath the sea prior to the coming of animals and plants upon the earth. They survived to perform a most important office, for they form the skeleton upon

which the North American Continent, such as exists at present, is built.

To the westward extended a vast tract of shallow seas, with here and there, as in Wisconsin, Missouri and Arkansas, a small barren island. Great banks and shoals, not unlike those which at present underlie the fishing grounds off the coasts of Newfoundland, existed where now stands Cincinnati, and in many places besides. As now the beaches of New Jersey slope downward with such a gentle declivity that it is not until we have gone eighty or a hundred miles from the shore that we make the grand plunge and reach the terrible abyss of mid-ocean, so then the eastern shores of this narrow V-shaped continent probably were quite shallow over eastern New Jersey, Delaware, Maryland, Virginia, North and South Carolina, Georgia and Florida.

If you will have the patience to follow me, we shall endeavor to travel together in company along the western shores of this continent, and trace out its windings and bays and gulfs. We shall stop to consider the furrows and marks of ancient tides and waves and storms, while here and there the traces of seaweeds and stranded crab or shell will for a moment delay our steps.

The labors of the many eminent men who have spent months of pedestrian travel and years of profound thought in determining this coast-line teach us that it approached nearest to the present site of this city at a point on the Philadelphia and Westchester Railroad, a few miles to the eastward of Media. It then followed a southwesterly direction through Chadd's Ford, Kennett Square and New London, leaving the State a few miles on this side of the crossing of the Susquehanna into Maryland at the State line. From this point it extended through western Maryland, Virginia, North Carolina and Georgia, almost if not quite to the middle of Alabama. Tracing it to the north-eastward, from the point on the Westchester Railroad where we first set foot upon this ancient shore, we follow it round a long cape which jutted out into the sea at Castle Rock, Marshalton and Locust Grove, and then crossing the present bed of the Schuylkill not far from Conshohocken, extended on until it passed out of the State at Trenton. To the westward of this continental seabeach were a number of long islands, some broad, some narrow, which formed a succession of sounds lying one beyond the other, very much of the same kind as we find along the coast of North Carolina at the present day. Crossing the northern angle of

New Jersey, it followed the Hudson to Lake Champlain, and then swept around to the south-westward, forming a great gulf along the valley of St. Lawrence, and enclosing the whole of northern New York in a great peninsula joining on to the mainland at the eastern angle of Lake Ontario. From this point it followed a line running not far from the northern boundaries of Canada to Lake Huron, and thence along the southern shore of Lake Superior, through Wisconsin, Iowa and Minnesota, north-westward to the Rocky Mountains.

Although nothing green or living could have been seen by any explorer upon this desert shore, yet it was not without some diversity of scenery. Along the Pennsylvania shore were low hills and broad valleys, with here and there a creek or river running downward to the sea. Inland from the Canadian beach were higher ranges, acclivities which in many cases probably exceeded a thousand feet in height. These primeval rivers carried down with them fragments of feldspathic and talcose rock, and oftentimes were turbid with soil washed inward from their banks. Layer after layer of these materials were laid down upon the ancient shore, and hardened by heat from within and from without, consolidated by the weight of later rocks deposited upon them, gradually became laminated stone. Their strata are never parallel to the underlying rocks, but tilt against them at some angle, the degree of inclination greatly varying. In Pennsylvania so greatly have they been crumbled and folded, that everything living or organic which they may have contained has perished utterly. Even the thickness of these distorted beds is with great difficulty to be estimated. Probably, however, they did not fall far short of a quarter of a mile in depth.

A period of greater regularity and quiet appears to have followed the deposition of these earliest beds. It is marked by the presence almost everywhere along this coast line of more than two thousand miles in length, of deposits of fine white and yellowish sand. Though of sand, it is by no means a dead and trackless waste. On the contrary, if we could wander over this wide strand, we should find a myriad of marks and tracings which would engage our earnest study, and certain remains indeed so peculiar that no beach, however beautiful, could so richly repay a walk upon it. The waves that beat upon this beach have not died away and left no sign; the tides have registered themselves as unerringly and far more en-

duringly than any tide-measurers which man's ingenuity has yet set up. We can follow the pathway of the storm and note the direction of the wind. Enough remains to tell us what kind of atmosphere and climate existed at that incredibly remote era. We do not imagine vain fancies when we picture to ourselves the rays of the sun piercing down through the cloud-laden sky and lighting up the sandy reaches of the primeval shore, and striking across slope and glen. Whatever doubt be entertained concerning the presence of life in the underlying strata, no one will question that upon these sandy beaches there flourished plants and animals, which drew from air and sun and water their strength and sustenance.

As we turn over some great slab of sandstone which once formed a part of this beach, we find its surface covered with delicate curving and recurring lines, interlacing one with another in the network of fantastic tracery. Is there nothing familiar to the experience of every one of us which may serve to explain the riddle? Many a time, perhaps, while idly sketching the fabric of sea-side reveries upon the ocean shore, we have followed the breakers as they ran out their long lines of creamy spray, each successive one lower than that which had gone before, until at last in one broad sheet they ran up the beach and marked their limits by a faint furrow and pencilling in the sand. When gentle breezes caught the retreating wave and tossed it into tiny ripples, they were mirrored in the yielding sand beneath, and when preserved by the hardening of the mould, they were recorded imperishably. Sometimes, too, we encounter upon the sandstone diverging lines of broken shell and pebble, which point to some obstacle that has hindered the down flow of the retreating wave, and caused it to drop a portion of the booty that it had snatched from a higher level. And often on the seaward side of such an obstacle, a wedge-shaped pit, where the rapid movement of the eddy which it formed prevented the deposition of the sand behind it. These rocks in many places are pierced through and through by a marine worm, called the *scolithus linearis*, which found a living just along the water's edge. Though its long, fleshy body has perished, yet its place has been subsequently filled in with sand, and so numerous and widespread are these worm-like cylinders of sand that their presence is in the highest degree characteristic of the time and circumstances which we are at present studying.

We follow a layer in these sandstones until it thins out to a knife-edge and then disappears. Above and below it are other layers

made up of sand coarser or finer, of pebbles great or small, sometimes laminated parallel, at other times obliquely to the surface, and here a few lines and there many inches in thickness. All these appearances point to a time when these sandstone slabs were sand, and were piled up by the ebb and flow of the tide, or spread out upon the beach by ocean currents. Not less indicative of an exposed shore are little hillocks of sand with their crests blown away, and other hillocks covering their tops, or sloping up against their sides from a different quarter—wind-guages, as it were, which serve to tell us of the direction and strength of the winds which blew some thousands of centuries ago. And if these failed us, there are not lacking other marks quite as full of significance; as, for example, little pits, sometimes scarcely to be perceived, looking as though made by a gentle rainfall pattering downward directly from above, and then again ploughed in to north, or south, or east, or west, according as the tempest raged from one or another quarter. Where the sand is mixed with clay or mud carried down to the sea from some creek or estuary, it has shrunk as it hardened on exposure to the sun, and has cracked into a thousand intersecting fissures. Subsequently these have been filled in with a softer or denser, a lighter-colored or darker material, and when allowed to decay under the action of the weather are traversed by furrows or cut up by hard ridges, like a honey-comb, as the case may be. At times, some of the little marine animals left their dwelling, on excursions for business and pleasure, and if the breezes which swept along the shore happened to be laden with sand, they filled up the foot-marks of the traveller, and recorded the story of his wanderings for our amusement and instruction.

But very little went on in these early times of which we have no hint or tidings. If some mean worm vanished, a grave at least was necessary for his burial, and the grave without its inhabitant has come down to us. If the sun was much obscured by fogs and clouds, we have the Trilobite with great staring eyes like horns to tell us that it was needful for such a big fellow to make the most of the light there was, to get his food and living by. No tide that ebbed or flowed for countless centuries passed away without leaving some rill or ripple-mark to preserve its memory to the remotest reach of time. Even the fickleness of the wind and its veerings to and fro are as patent to the observer upon the shores of this ancient sea, as to him who has looked to-day upon its constant shifts and whirls.

Will the countless volumes written upon papyrus, and parchment, and paper, graven in brass or cut in stone by the hand of man, be one-half so enduring?

This beach reveals to us the beginnings of vegetable life; plants of little interest to the botanist so far as their structure is concerned, or to the curiosity-seeker, so far as relates to their beauty—but to him who is intently watching the world's development, of the highest import. These plants were fucoids, not of the delicate forms and exquisite tints which insure them a welcome place in the albums of lady visitors to the sea shore, but looking more like leathern aprons. The tissue of the sea weed has never been found in a state of preservation. But sometimes the fact of its existence is made known to us by the thin seams of mineral coal into which the stems and aprons of these sea weeds by heat and pressure have been converted. Few as are the forms of these marine plants which have been preserved to us, and homely as was their appearance, yet we cannot overestimate their importance. To them, the animals which appeared at a later period of the world's development were indebted for the material of nerve and tube and muscle. It was only the stuff of shell or skeleton which the animal could elaborate directly from the waters of the sea. And so prolific are these sandy beaches in relics of animal as compared with plant life, that two ideas suggest themselves as of great probable truth, and worthy of careful testing by a scrutiny of these sandstone rocks. The first is that a vast number of minute vegetables, which served to nourish animal life have hitherto escaped detection, or have been so pulverised and broken that they can never be distinguished. We know of the existence of similar plant-growths occurring in rocks of subsequent origin, and although of such microscopic dimensions as that millions of their flinty shells compacted together do not make up the bulk of a cubic inch, yet huge masses of rock are built entirely out of them. These infusoriæ were builders in flint—withdrawing silex from the water and storing it up in their stony skeletons. Their co-laborers the corals preferred limestone as a building material, each tiny workman bequeathing the house he had built and in which he lived to the coral community at his death.

The second idea which has suggested itself in this connection is that the sea differed at that period very widely from its present composition, and was very much more charged with mineral matter than now. Our daily observation teaches us with what energy the air and frost

and sun, ice and moving water are operating upon the earth's crust at the present time. The decay of plants forces itself upon our attention from the fact that the beautiful shapes of leaf and flower and branch are quickly lost, and the vivid coloring of life is exchanged for the ugliness and blackness of death. Rocks are rotting surely and rapidly too. But their covering of soil, and the likeness of the decayed to the solid stone, hide their dissolution from the casual glance. The rain drop which falls from heaven is not the emblem of purity that we poetically imagine it to be. It has caught up in its descent impurities of many kinds. It is laden with nitrogen and its compounds, with microscopic germs capable of producing and sustaining life, and with carbonic acid. As soon as the latter comes in contact with gneiss or schist or granite, it is busy at its work of corrosion. Salts of soda and potash and lime, of iron and magnesia, are being extracted from their storehouses in the hills, and fed out to the world in countless tons yearly, just as the requirements of its organic growth demand. An elevation of the earth's temperature by a few degrees would heighten the solvent power of the water and increase the manufacture of every salt enormously, and without precipitation from the sea or the number of rock-forming plants and corals, increased in the same proportion, would make of the ocean another Dead Sea.

(To be continued.)

THE SUN.

A Course of Five Lectures, before the Peabody Institute of Baltimore.

By Dr. B. A. Gould.

(Continued from Vol. LXI, page 201.)

In the general programme laid out for these lectures, the present one was assigned for the consideration of physical investigations into the constitution of the sun, while the second treated of the appearance manifest to the observer. Although the two subjects appear sufficiently distinct, yet the boundary line between them is shadowy and undefined, inasmuch as the greater portion of our physical researches must necessarily be made by means of direct observation of the sun's aspect. Therefore I will make no apology for beginning my discourse this evening with a few words

more regarding the spots in certain respects which bear closely upon questions of solar physics, although it might have been more appropriate to discuss them in my last lecture, had my other remarks been less extended.

I have said that the spots are undergoing continual changes of form and aspect. The amount of these changes and the magnitude of the actual motions which they seem to imply is truly marvelous. One observer* estimates the velocity of the flashes across the penumbra, by which bridges of light are formed, as 125,000 miles in a second; and cases are by no means rare in which the dimensions of a spot have been seen to change by a couple of thousand miles in a single hour. The photographs which Prof. Mayer obtained in August, 1869, and which I have already shown you, exhibit different views of the same spot, taken before and after the total eclipse. The interval between the two was less than two hours, during which time the nucleus had widened by 1,800 miles in one direction, and narrowed by 2,350 miles in another, while the transformations perceptible in the group immediately north of the large spot indicated an equally intense activity there. I do not myself believe that any actual transference of matter occurred with the rapidity which appearances would indicate, and as for the projection of the luminous particles with such a velocity as 125,000 miles a second, or even the hundredth part of this, it is highly improbable; but that the *appearance* of such motion has been exhibited, cannot be doubted.

The natural history of the solor spots is full of interest; the phenomena of their first outbreak, their development, and their dissolution have been described in great detail by many observers; and the published descriptions of the curious processes there seen in action would fill volumes. There seems also to be more than one kind of spot, some being deep and others apparently superficial,—some with penumbra, and others without it; but our limits forbid me to enter into any detail in their description, other than a brief summary of the general facts. Originating as black points, (like one of those, of which so many exist at all times upon all parts of the sun,) or formed by the aggregation of several of these, they increase rapidly in size, soon developing a penumbra, which increases with equal rapidity, until, generally in the course of a single day, they arrive at the full maturity of their dimensions, and

*Peters.—Proc. Amer. Assoc. Adv. Science. 1855. p. 94.

thereafter continue their existence, though with largely fluctuating outlines, during a period of uncertain length, usually from twenty to forty days, and sometimes even for three or four months. For the first few days they usually exhibit a tolerably roundish form, with regular and uniform penumbra. Then the irregular indentation of the margin, always visible with a good telescope, but generally quite slight at first, become deeper and deeper, until at last they actually divide it into segments; the boundary of the nucleus becomes similarly affected, and a period arrives at which the formation of bridges begins, which cross the nucleus and subdivide the spot into two or more parts; these in their turn being again divided into yet smaller ones which gradually contract and disappear. During this process of destruction whole tracts of penumbra are sometimes seen to break away from the rest and gradually fade from sight in the dark chasm of the nucleus; and so, too, portions of the photosphere or glowing outer surface have been seen to cave in, as it were, and, traversing the penumbra, to lose their brilliancy by degrees and to become extinguished in the central cavity. Even isolated granules have been seen to detach themselves from the edge and follow the same course; and careful scrutiny has shown that the granules of the photosphere all around the margin point inward; that in the bridges all the granules are parallel, extending lengthwise like straws closely packed together, and that the decrease of brilliancy in the penumbral or photospheric matter, as it disappears in the yawning void, is due to a diminution both in the size and the brightness of the individual granules. These observations are of great importance, for they suggest a vaporization as they disappear, as well as some strong polar attraction, whether electrical, chemical, or otherwise, which leads to the formation of bridges as well as to the radiating arrangement of the granules around the spot.

Many interesting observations have been made regarding the mutual relations of the various spots in a group, the order of their formation and disappearance, and their mode of developement. So, too, have curious facts been gathered concerning the tendency of spots to rotate around their centre, and the various tints observable in their nuclei. But all this must be passed over, for our subject is large, and our limits are narrow.

The great fact, to which I have more than once alluded, that the sun is practically our only source of earthly power and energy,

gives a peculiar interest to the question whether his brilliancy or thermal energy are undergoing any perceptible diminution. That they are diminishing, we must assume on general principles, inasmuch as we know to what an inconceivable extent he is radiating force in the various forms of heat, light and chemical power; and force, once emitted from a source of such superior energy, is not returned to it again; while a new creation of force by natural agencies is just as impossible as a new creation of matter. But whether any diminution of radiant energy in consequence of the enormous expenditure is perceptible by our means of investigation is a most natural and important question, and to this it must be answered that no appreciable decrease has been detected. Few observations available for the purpose have been bequeathed to us by the astronomers of former days; but from some careful observations* which the distinguished astronomer Olbers made in 1801 upon the brilliancy of Mars which depends of course upon reflected solar light. Prof. Seidel of Munich was able to prove† in 1859 that the solar light had not diminished in the interval to any measurable extent. It has been well said that had some of the old Greek metaphysicians once dipped a thermometer into the Ilisuss and recorded the date and temperature, it would have added a thousand fold more to our knowledge than all their speculations did. We can forgive them for this omission, if for no other reason than that they had no thermometer to dip; but had they even so much as recorded the average date of flowering of any common plants, we should be able to thank them for at least some materials whence we could obtain valuable geological and cosmological knowledge.

In 1845 our countryman, Prof. Henry, succeeded in discovering‡ that the spots radiate less heat than other portions of the sun's surface; Secchi has also shown§ that the amount of heat which reaches us from portions of the disk near the margin is less than from the centre, in the same way as is the case with solar light and apparently according to the same law; so that a region of the disk 22″ distant from the limb emits only half as much heat as is emitted from one of equal area near the centre; and we are thus justified in considering that where we observe differences in the inten-

*Zach's *Monatl. Correspondenz*, Oct. 1803.

†*Monum. Sæc. d. K. Bayerichen Akad.* "*Untersuchungen über die Lichtstärke der Planeten*," etc.

‡Mem. Amer. Phil. Society. IV., 173.

§*Comptes Rendus.* 1852.

sity of solar light, there also are corresponding differences of solar heat. The total brilliancy and warming power of the sun must vary somewhat with the area upon his surface which is occupied by spots, and the labors of Schwabe, in Germany, of Wolf, in Switzerland, and of Carrington and the Kew observers in England, have afforded much valuable information on this subject during recent years. Messrs. De La Rue, Stewart and Lœwy, under whose directions very thorough measurements have been made of the area of the spots as delineated on Carrington's charts, have published* a table showing the proportionate area upon the face of the sun which was occupied by spots on each day comprised in his series of observations. The largest amount of spotted surface, which I find in this seven years' series was on September 1, 1859,

Frequency of Spots on the Sun.

Year.	Number of Days.	Number of Groups.	Days without spots.	Year.	Number of Days.	Number of Groups.	Days without Spots.
1826	277	118	22	1848	278	330	0
1827	273	161	2	1849	285	238	0
1828	282	225	0	1850	308	186	2
1829	244	199	0	1851	308	151	0
1830	217	190	1	1852	337	125	2
1831	239	149	3	1853	299	91	4
1832	270	84	49	1854	334	67	65
1833	267	33	139	1855	313	79	146
1834	273	51	120	1856	321	34	193
1835	244	173	18	1857	324	98	52
1836	200	272	0	1858	335	202	0
1837	168	333	0	1859	343	205	0
1838	202	282	0	1860	332	210	0
1839	205	162	0	1861	322	204	0
1840	263	152	3	1862	317	160	3
1841	283	102	15	1863	330	124	2
1842	307	68	64	1864	325	130	4
1843	312	34	149	1865	307	93	26
1844	321	52	111	1866	349	45	76
1845	332	114	29	1867	312	25	195
1846	314	157	1	1868	301	23	101
1847	276	257	0				

on which day $\frac{41}{100}$ of one per cent. of the disk consisted of spots; about four-fifths of this amount being penumbra, and one-fifth of it nucleus. On the other days the degree of spottiness varied between this maximum amount and an entire absence of all spots. This variation is itself by no means without regularity, but is governed to a considerable degree by a curious law. In 1843, after

*Researches in Solar Physics. Second Series.

Schwabe had carried on his spot observations for sixteen years, he discovered that their frequency was periodic, so that, while in 1828 and 1829, and also in 1836 and 1839, there was no day upon which spots were not visible, there were on the other hand more than one-third of all the days in 1833 and 1843 when no spot whatever could be detected. Hence the existence of a periodicity in their recurrence was manifest, and he estimated the length of the period at about ten years.* Subsequent observations have fully corroborated this important discovery, and the accompanying tabular view presents a summary of the results obtained by Schwabe since the beginning of his series of observations.

The great extent of the periodic variation will readily be recognized upon a glance at the third and fourth columns of this table, and it should be added that the abundance of the faculæ appears to follow the same law as that of the spots, being greatest when the latter are most frequent, and disappearing to a great extent during the spotless seasons.

(To be continued.)

MINERALOGICAL NOTES FOR 1870.

By Wm. H. Wahl.

New Minerals.—From various available sources of reference it appears that during the year 1870, about eleven new species have been added to the catalogue of minerals, with the usual abundance of new varieties. The following historical list will suffice to give a general idea of the character of the new additions.

Glaukopyrite.—Announced by Prof. F. Sandberger, occurs at Guadalcanal in Spain, associated with Calcite, Tetrahedrite, Pyrargyrite and sulphide of antimony. It is described as occurring in rounded aggregations, which when magnified are found to be composed of a series of thin layers. The structure is mainly finely granular. Crystals are not sufficiently developed to be definitely determinable, but Sandberger suspects them to belong to the orthorhombic system. He also believes that he has detected twins and triplets, bearing a general resemblance to those of Cerussite. The mineral is described as follows: Lustre, metallic; color, light lead-gray, approaching tin-white; streak, grayish black; hard, 4; specific gravity, 7·181.

**Astron. Nachrichten.* XXI., 234.

The chemical examination gave the following as its constitution :

Sulphur	2·36	Iron	21·38
Arsenic	66·90	Cobalt	4·67
Antimony	3.59	Copper	1·14

The species approaches nearly to the Geyerite of Breithaupt, but differs in color, specific gravity, and in containing copper. It would fall in Dana's pyrites division as a member of his Marcasite group.

Rabdionite is the name assigned by v. Kobell to a new metallic mineral, belonging to the class of hydrous oxides of which Wad and Asbolan are representatives It differs, however, from the latter, which it approaches very nearly in chemical composition, in several important particulars. It is crystallized, occurring in short prisms; it has more water, and is more readily fusible. Its characteristics are described as follows: Color, black; mat; streak, dark brown; very soft, so that taken between the fingers it readily rubs away, leaving a stain behind.

Namaqualite.—Church describes under this name a new copper ore, from Namaqualand, South Africa. It is described as occurring in thin, fibrous masses, alternating with silicate of copper. Color, light blue; lustre, silky; hardness, 2·5; specific gravity, 2·49. It consists mainly of oxide of copper, alumina and water, with small quantities of magnesia, lime and silicic acid.

Phosphorchromite—Occurs at Beresowsk upon Listwänite, associated with Crocoisite and Pyromorphite. It occurs in spherical aggregates, the surfaces of which display minute crystal facets. Internally, the spheres are partly crystalline and partly dense in texture. The mineral is described by R. Hermann as follows: Color, dark green; streak, lighter; hard., 3: sp. gr., 5·80. The analysis gave:

Plumbic oxide	68·33	Chromic acid	10·13
Cupric "	7·36	Phosphoric acid	9·94
Ferrous "	2·80	Water	1·16

Epiboulangerite.—Websky describes a new ore from Altenberg, occurring with Mispickel, Blende, Galena and Pyrites. It occurs in needles of a dark gray color. Though not suggested by the author, it may prove to be analogous in crystallization to antimony glance, as it is, in chemical constitution. It differs from Boulangerite, of

which it is doubtless a changed product, in containing from 21 to 22 per cent. of sulphur.

Amblystegite.—G. vom Rath gives this name to a new member of the Pyroxene group containing alumina. The mineral occurs in the curious Sanidin bombs from the remarkable volcanic region of Lake Laach, in the Eifel. The new mineral was long held by Wolf, the well known historian of Laach minerals, to be an Olivin, to which its crystallization (orthorhombic) bears a close resemblance. The pyramid is, however, much more obtuse, (measured over the macrodiagonal edge, it gives 125° 58½″, and the dimensions of the axes are determined to be $a : b : c = 0·97 : 1 : 0·570$.) Its cleavage is described to be inappreciable: hard., nearly 7; sp. gr., 3·4; color, brown to reddish-brown; lustre, adamantine. Chemical composition:

Silicic acid	49.8	Alumina	5·05
Ferrous oxide	25·6	Lime	0·15
Magnesia	17·7		

Uranotil.—Boricky gives this name to a mineral occurring in a drusy quarz which coats the surface of feldspar at Walsendorff, in Bavaria. The character of the occurrence is in fine needles, which v. Zepharovich determines to belong to the orthorhombic system. The needles display frequently a radiated structure. Color, lemon-yellow; sp. grav., 3·95; streak, lighter. The mineral blackens before blowpipe. Constitution:

Uranium sesqui oxide	66·752	Silicic acid	13·781
Alumina (Ferric oxide)	0·511	Pposphoric acid	0·448
Lime	5·273	Water	12 616

Both in crystallographic and chemical character it approaches the Uranophan of Websky.

Jacobsite.—A new spinell is described by Damour under this name. It crystallizes in ocahedra, which are frequently much distorted. Color, black; lustrous, opaque; hard., cuts glass; sp. gr., 4·75. It contained, according to analysis, 4·21 per cent. of peroxide and 20·57 per cent. of the protoxide of manganese. The peroxide constituent is chiefly iron. Small quantities of magnesia and zinc oxide are also present. It may therefore be termed a manganese spinell. It occurs at Jacobsberg, in Sweden, in crystalline limestone, associated with silvery mica and particles of native copper.

Gümbelite.—Named by v. Kobell in honor of the geologist, Gümbel, is described as a greenish-white mineral, of a pearly or silky lustre; translucent, soft and flexible, and like asbestos to the touch. Occurs in Oberfranken. It consists essentially of a hydrous silicate of alumina, containing likewise a small proportion of potash and ferric oxide.

Milarite.—A new Swiss zeolite occurring in a granite rock in company with smoky Quartz, Orthoclase, Apatite, Chabacite, &c., is described by Prof. Kengott. Its crystallization is hexagonal, the forms being small but sharp, and combinations of prism and pyramid of both orders, (the polar interfacial angle of pyramid = 144° 46′ 5″.) The analysis shows it to be a hydrous soda, lime and alumina silicate. Its name is derived from its occurrence in the Val Milar. Color, white to green; hard., 5·5-6.

It will be noticed that Gmelinite, which approaches very nearly in chemical character, presents a further resemblance to the mineral just described, in its crystallization, which is hexagonal (holohedric.) The angle of its pyramid is 142° 25′, a variation of but 2° from the measurement which Kengott announces for Milarite.

Hessenberg describes likewise another zeolite from the volcanic region of Santorin. The crystals are short orthorhombic prisms. Before blowpipe it swells considerably and fuses readily to white glass. Prof. H. describes it as very closely resembling Epistilbite. From the similarity, almost identity, of the angle of the prism (the difference scarcely amounts to 1°), it would seem highly probable that the two were the same.

Sandberger describes several new hydrated phosphates, one of which, a phosphate of lime, is analogous to the hydrated phosphate of copper, known as Libethenite. The crystals are colorless, belong to the monoclinic system, and possess a prismatic habitus. No name has as yet been proposed for it.

Simonyite is a new sulphate, found in the salt works at Hallstadt, and described by Tschermak. It occurs associated with Rock-salt and Anhydrite, chiefly in thin layers of a blueish-green color, presenting here and there a crystalline form, which is announced to be monoclinic. It is a hydrous magnesia-soda sulphate.

Of the numerous varieties which have been announced, the following seem to be the most interesting:

Lithiophorite.—An ore of manganese, containing lithia. It is amorphous, occurring in thin layers; also, pseudomorphic after

Calcite. It colors the flame intensely red. It is found in the granite of Schneeberg, Schwartzenberg and Johanngeorgenstadt—generally coating Quarz. The granite is much decomposed, and with the spectroscope gives distinct indications of the presence of lithia.

A new Olivine.—Roepper gives the following as the composition of a mineral occurring in crystals of an inch or two in length, at Sterling, N. J. It is found associated with Willemite, Franklinite, Jeffersonite and Spinell.

Silicic acid	29·90	Oxide of Zinc	10·66
Iron protoxide	35·C0	Magnesia	5·81
Oxide of Manganese	16·90	Insoluble	1·03

The crystalls were weathered externally, but within were bright. Color, dark green to black; hard., 5·5—6. A zinc deposit was obtained with the blowpipe. The crystallization and analysis prove it to be an Olivine. The proportion of zinc and manganese in its composition make it a most interesting variety.

The same author describes a *manganese Dolomite*, from or near the same locality. It is a rosy-red mineral, occurring in a vein of apple-green Willemite. It possesses distinct rhombohedral cleavage. Hardness = 4; sp. gr., 3·05. An analysis gave as much as 43·5 per cent. of carbonate of manganese, 50 per cent. of carbonate of lime; the remainder consisting of carbonate of iron and magnesia. Accordingly Roepper characterizes it either as a Dolomite in which the magnesia has been replaced almost entirely by manganese, or as a Daillogite, in which a large proportion of the manganese has been replaced by lime.

Hallite, a micaceous (or chloritic ?) mineral from Chester county, Pennsylvania, has been announced by Leeds. It is flexible, of a brownish color, and occurs in plates of various sizes. It is believed to possess distinguishing optical properties, though no investigation of the subject has yet appeared.

Metacinnabarite.—G. E. Moore has announced the occurrence, in Lake county, California, of an amorphous sulphide of mercury in a silicious gangue, in company with Cinnabar. It frequently covers crystals of Pyrites, and is filled with small cavities in which are found crystals of Cinnabar. The color is greyish-black; streak on porcellane, pure black; hard. = 3; sp. gr., 7·7. It gives all the reactions of Cinnabar, with which it is identical in composition. The author very properly identifies it as the variety of sulphide obtained in the laboratory as an amorphous black powder, upon precipitating a soluble mercuric salt. He proposes the name given above to designate the variety.

Franklin Institute.

Proceedings of the Stated Meeting, March 15th, 1871.

HALL OF THE INSTITUTE, March 15, 1871.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair. The minutes of the last meeting were read and approved. The Actuary submitted the minutes of the Board of Managers, and reported that at the stated meeting held March 8th inst., donations to the library were received from the Society of Arts, the Institute of Civil Engineers, Lt. Gen. Edward Sabine, London, England; Hon. U. S. Secretary of State; Hon. W. D. Kelley, Washington, D. C., and Messrs. Hillibrand and Wolf, Philadelphia.

The committee appointed to report on the estimation of the horse-power of engines and boilers reported progress.

The Secretary then read his monthly report on Novelties in Science and the Mechanic Arts. Upon which the meeting adjourned.

W. H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, April 19th, 1871.

The meeting was called to order by the President, Mr. Coleman Sellers. The minutes of the last meeting were read and approved. The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting held April 12th, donations to the library were received from the R. A. Society; the Statistical Society and the Society of Arts, London; from L. A. H. Latour, Montreal, Canada; the Mercantile Library Association, San Francisco, California; the Board of Water Commissioners, Detroit; Michigan; Thomas U. Walter, Germantown, Philadelphia; Mrs. Wm. Swain, West Philadelphia; The American Pharmaceutical Association and George M. Conarroe, Esq., Philadelphia.

The President thereupon announced the paper of the evening to be on the Use of Pulverized Fuel, by Lieut. C. E. Dutton, U. S. Arsenal at Frankfort. The paper was an exhaustive treatment of

the subject, particularly describing the process invented by Messrs. Whelpley & Storer.

The committee appointed to examine and report upon the different methods of estimating horse-power reported progress, and were continued.

The Secretary then read the monthly report upon Science and the Mechanic Arts; and Prof. Rogers presented to the Institute a description of a new discovery of his, in the application of air with steam in the steam engine. The meeting thereupon adjourned.

Extract from the Minutes of the Board of Managers, Stated Meeting, June 14th, 1871.

"The Committee on Publications presented the following letter from Prof. Morton:—

STEVENS INSTITUTE OF TECHNOLOGY, HOBOKEN, N. J.
June 3d, 1871.

The Committee on Publications of the Franklin Institute.

Gentlemen:—The experience of the past year has shown that at this distance, and with the many other demands upon my time which now exist, I cannot give that attention to the affairs of your *Journal* which the office of an editor ought to imply. I therefore beg leave to present my resignation of that office, while at the same time, I tender you my sincere thanks for the steady support which you have given to my efforts in connection with the *Journal*, and my earnest wish for its continued success in the hands of my able co-editor, Dr. Wahl.

Respectfully yours,

HENRY MORTON.

On motion it was resolved that the Committee recommend to the Board the acceptance of the resignation proffered in the above. The Committee further recommend to the Board the passage of the following resolution.

Resolved, That the thanks of the Board be tendered to Professor Morton for his services in behalf of the *Journal*, since his active connection with the Institute.

The proffered resignation was thereupon accepted and the resolution was unanimously adopted.

WM. H. WAHL, *Secretary.*

HARVARD UNIVERSITY, CAMBRIDGE, MASS.

LAWRENCE SCIENTIFIC SCHOOL AND MINING SCHOOL.

The Academic Year begins on the Thursday following the last Wednesday in September, and ends on the last Wednesday in June. The examination for admission to the Scientific and Mining Schools will be held on September 28, 1871, beginning at 9 A. M.

INSTRUCTORS.

LOUIS AGASSIZ, LL. D., Professor of Zoology and Geology.
BENJAMIN PEIRCE, LL. D., Professor of Astronomy and Mathematics.
ASA GRAY, LL. D., Professor of Natural History.
JEFFRIES WYMAN, M. D., Professor of Anatomy.
HENRY L. EUSTIS, A. M., Professor of Engineering.
JOSIAH D. WHITNEY, LL. D., Professor of Geology.
HERMANN A. HAGEN, M. D., Professor of Entomology.
WOLCOTT GIBBS, M. D., Professor of the Application of Science to the Useful Arts.
JOSEPH WINLOCK, A. M., Professor of Astronomy and Geodesy.
JOSIAH P. COOKE, A. M., Professor of Chemistry and Mineralogy.
JAMES M. PEIRCE, A. M., Professor of Mathematics.
CHARLES FREDERICK HOFFMANN, Professor of Topographical Engineering.
RAPHAEL PUMPELLY, Professor of Mining.
WILLIAM H. PETTEE, A. M., Assistant Professor of Mining.
NATHANIEL S. SHALER S. B., Professor of Palaeontology.
JOHN TROWBRIDGE, S. B., Assistant Professor of Physics.
PIERRE J. BORIS, Instructor in French.
WILLIAM G. FARLOW, M. D., Assistant in Botany.
CHARLES L. JACKSON, A. M., Assistant Professor of Chemistry.
JOSIAH C. BARTLETT, A. B., Instructor in Mathematics.
HENRY B. HILL, A. B., Assistant in Chemistry.
GEORGE THEODORE DIPPOLD, Instructor in German.
CHARLES EDWARD MUNROE, Assistant in Chemistry.

LAWRENCE SCIENTIFIC SCHOOL.—This School has been reorganized and now offers:

1. A four years' course of study for the Degree of CIVIL ENGINEER, as follows:—First Year—Spherical Trigonometry; Analytical Geometry; Descriptive Geometry; Chemistry; Surveying and Plotting; Road-making; Free-hand and Water-color Drawing; French. Second Year—Differential and Integral Calculus; Mechanics; Physics; Mathematical and Physical Geography; Elementary Geology; Crystallography, Mineralogy, and the use of the Blow-pipe; Mechanical Drawing: French: German. Third Year—Applied Mechanics; Practical Astronomy and Geodesy; Hypsometry; Topographical Surveying and Drawing; Structural and Dynamical Geology; Photography; German, Fourth Year—Building Materials, and their applications in railroads, canals, bridges, etc.: Applications of Descriptive Geometry to masonry and stone-cutting; Hydraulics; Heat and its applications; Discussions of existing structures, and working out of projects.

Candidates for admission to this course on Engineering (unless they are graduates of colleges) will be examined in Arithmetic, Algebra, Geometry and Trigonometry; and will also be required to show that they are reasonably proficient in English Grammar and Geography.

2. A one year's course of study in the elements of NATURAL HISTORY, CHEMISTRY AND PHYSICS, as follows:—Physical Geography, Meteorology, and Structural Geology; General Chemistry and Qualitative Analysis; Physics; Botany; Zoology; Entomology.

This course is especially intended for teachers or persons who intend to become teachers. The instruction will be mainly given in the laboratories and museums of the University; it will be of the most practical character, every student being taught to make experiments and study specimens himself.

3. Thorough instruction for advanced students in any of the following subjects:—PHYSICS (Heat and Light); CHEMISTRY; ZOOLOGY; GEOLOGY: BOTANY; and MATHEMATICS.

Professor Gibbs will receive special students in Heat and Light at the Rumford Laboratory. Professor Cooke will receive special students in Chemistry at the Laboratories in Boylston Hall. Professors Agassiz, Hagen and Shaler will receive special students in Zoology and Geology at the Museum of Comparative Zoology. Professor Gray and Assistant Farlow will receive special students in Botany at the Botanic Garden and Herbarium. Professors Benjamin Peirce and James M. Peirce will receive special students in Mathematics.

The opportunities for advanced students in all branches of Natural History and in Physics, Chemistry, Astronomy and Mathematics will be much greater next year than ever before. The Museum of Comparative Zoology has been more than doubled in size during the current year; a laboratory, lecture-room and green-house have been added to the equipment of the Botanical Department, a Laboratory of Physics is to be created during the summer in Harvard Hall, the Chemical Laboratories are to be greatly enlarged and improved, the interior of the Scientific School Building is to be completely reconstructed, and a distinct Physical Laboratory and Cabinet are to be assigned to the Rumford Professor. At the same time the scope and volume of the instruction will be greatly enlarged.

MINING SCHOOL.—The full course, prescribed for candidates for the degree of Mining Engineer, occupies four years, the first three of which are identical, as regards the subjects of instruction and the order thereof, with the first three years of the Engineering course above specified. The terms of admission are the same as those of the Engineering course. The fourth year of the course is as follows:—Economical Geology and the Phenomena of Veins; Mining Machinery and the Exploitation of Mines; General and Practical Metallurgy; Assaying; Working up, Plotting, and Writing out notes of summer excursions.

FEES AND EXPENSES.—The tuition fee for the academic year, in any of the above departments or courses, is $150; for half or any smaller fraction of a year, $75; for any fraction of a year greater than one-half, the fee of the whole year is charged.

The other expenses of a student for an academic year may be estimated as follows:—Room, $?0 to $100; Board for 38 weeks, $152 to $304; Books, $20 to $25; Fuel and Lights, $15 to $35; Washing, $19 to $35.

For University catalogues, descriptive circulars, examination papers, or information about any department of the University, address J. W. HARRIS, Secretary.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. LXII.] AUGUST, 1871. [No. 2

EDITORIAL.

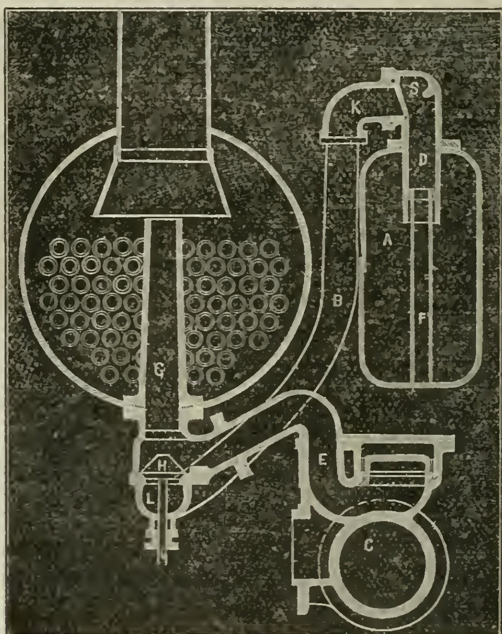
ITEMS AND NOVELTIES.

Lock-Nut and Washer.—At the last meeting of the Institute there was exhibited and described a lock-nut and washer, the invention of Mr. U. B. Vidal. The improvement claimed consists in the use of a nut, the inner face of which is furnished with one or more diagonal slots. The washer is of lead, and when in place a key is driven home into the slot on the face of the nut, which forms a counter-slot in the washer, and by this means firmly attaches the bolt.

The main purpose of the invention seems to be to provide a permanent joint for securing the fish-plates at the ends or joints of rails. The difficulty to be overcome is the effect of the excessive vibration given to the joints by the passage of trains, which being communicated to the bolts, rapidly loosens them. The inventor claims that the inelastic nature of the leaden washer obviates this source of evil, by absorbing these vibrations or failing to transmit

them to the nuts. Instead of keying, other methods of attachment are suggested as equally efficacious.

Tank Locomotive with Condensation.—In the figure represented below, the exhaust steam escapes from the cylinder through the pipe E, thence through the blast-pipe G to the chimney in the usual way; but at the base of the blast-pipe is fitted a double-faced conical valve under the control of the engineer by a system of levers and rods connected to the valve-stem J. A chamber L beneath this valve communicates with the condenser A through the connected pipes B, K and D; in the lower end of the latter, the cold water pipe F terminates and at its upper end the valve S is hinged, opening towards the condenser.



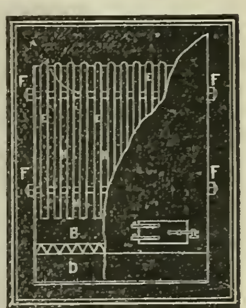
When it is desired to suppress the blast the valve H is moved to its upper seat I, and cold water is ejected through the pipe F into D from which it descends through the annular space around the top end of F into A, whence it may be forced into the boiler or thrown overboard.

A distance of 1000 metres may be passed over before it will be necessary to empty the condenser of water. Should the boiler be

fed therefrom the action of the condenser might be made continuous, but as the want of blast in the chimney would retard the generation of steam, the continued advantage of vacuum and suppression of blast could not be obtained.

This apparatus is, however, designed for temporary action, as while passing thoroughfares, tunnels, bridges and the like.—*The Praktische Machinen-Constructeur*, Leipzig, 1870, p. 274. J. H. C.

The Multi-Chambered Boiler.—The engraving annexed represents an elevation of the boiler, with part of the casing removed for the purpose of exhibiting the interior. B is the fire-place, D the stoke-hole, E E the chambers, constructed of the best wrought iron, F F shows the manner in which all the chambers are bolted together so as to form a boiler of many compartments.



"There are fillets of iron, which keep the individual compartments at a proper distance from each other; and the spaces which these fillets leave are the flues of the boiler, through which the flames ascend as shown at H H H. All these compartments are connected at the bottom for the purpose of keeping the water in each at the proper level; and at the top the steam is conveyed from each by as many pipes as there are chambers, into the steam feed pipe, by which steam is conveyed to the engines. By this arrangement, the only parts of the boiler which can be dreaded are the sides; but good ties will keep them together. And as to the bottom end, and top of the boiler, which are composed of the edges of these compartments, if one part is burnt out or hurt it is only that individual compartment which can burst, and its power of doing mischief is not worth notice."—*Walter Hancock's Steam Carriage Boiler, Mech. Mag., Feb.*, 1833, p. 79. J. H. C.

Narrow-Gauge Locomotives.—There are now being constructed at the Baldwin Locomotive Works (Messrs. Baird & Co.) several narrow gauge locomotives for the Denver and Rio Grande Railroad (3 feet gauge), As signalizing the "new departure" in railway practice, considerable interest naturally attaches to the fact.

One of the engines is already finished. It is six-wheeled, four of the wheels 40 inches in diameter, being coupled as drivers, and one pair of leading wheels in front having a swing bolster and radius bar, forming what is known as a "pony truck." The general plan

is similar to that of ordinary full-gauge locomotives. The cylinders are outside, and placed horizontally, and are 9 inches in diameter by 16 inches stroke. Its total weight, in running order, is 25,300 pounds, of which 20,500 pounds are carried on the four driving wheels, and so available for adhesion. A four-wheeled tender, having a water capacity of five hundred gallons and a coal capacity of about $1\frac{1}{2}$ tons, is attached.

The proportion of driving wheels relatively to the stroke of piston admits of a speed of thirty to forty miles an hour with equal facility as on the full gauge.

As an evidence of the interest now prevailing on the narrow gauge question, it may be stated that contracts have been received to furnish locomotives for several narrow-gauge roads, both in this country and Canada.

A huge Electro-Magnet.—Wallace & Sons, of Ansonia, Connecticut, have just delivered to the Stevens Institute of Technology a magnet which weighs in all about 1600 pounds. The coils are wound on eight brass spools, each $9\frac{1}{2}$ inches high by $11\frac{1}{2}$ inches external diameter. About 400 pounds of copper wire, $\frac{1}{5}$-inch thick, are wound on these spools, which are of course split and filled in with vulcanite. The cores are hollow, and 6 inches in diameter by 3 feet 3 inches in length. The lifting force of this magnet is estimated at between 30 and 50 tons. It will be five times as powerful as the one used by Faraday and Tyndall in their famous researches.

Marine Boiler Fittings.—The English Board of Trade has issued a circular to surveyors whose duty it is to see that the provisions of the Merchant Shipping Act are observed, from which it seems to be the intention of this Board that henceforth the employment of cast-iron pipes and other fittings in boilers on board steamships shall be prohibited, and that the use of copper or brass must be substituted for such fittings and pipes. Our cotemporary *Engineering* strenuously protests against the order, which it characterizes as an obnoxious and high-handed interference with manufacturing industry.

Testing Silver Plating.*—Dr. Böttger states that a cold solution of bichromate of potassa in nitric acid is an excellent test for the genuineness of a silver-plated surface. It is first necessary to thoroughly remove from it all dirt, grease or varnish, by washing with strong alcohol. A drop of the liquid is then applied, and at

* Dingler's Polytechnic Journal.

once washed off with water, when, if pure silver is present, a blood-red stain will be left where it had been applied. A number of other metals are stained, but none are so sensitive or so easily to be recognized as that of the chromate of silver.

Coal Supply of England.—The Royal Commission appointed some years since to examine into the condition and future prospects of the coal supply has, according to the *Times*, nearly completed its labors. The report is said to contain a demonstration of the fact that, allowing for an annual increase in demand, enough of economically available coal exists in the British Isles to meet the wants of consumers from 800 to 1000 years to come.

The appearance of the report will be looked for with interest by many who have imbibed the widespread popular impression, that the available supply of this all-important product was rapidly being exhausted by the long continued and constantly increasing drains upon the mines.

Decoration of Metals.—Dr. Puscher recommends a solution composed of a mixture of 3 parts of hyposulphite of soda and 1 of acetate of lead, for the purpose of decorating metallic surfaces. When heated to about 100° C., this solution deposits a layer of sulphide of lead upon any metallic surface in contact with it—the effect of the peculiar color of the metal beneath being to produce a great variety of tint.

Gun-Cotton is now manufactured in England to an amount exceeding 100 tons per annum. The cotton fibre is reduced to a pulp, as in paper making, in which condition the excess of acids is readily removed. The pulp is compressed into disks, under a pressure of 18 tons to the inch, and then dried. These disks are $\frac{7}{8}$-inch to 7 inches in diameter, and $\frac{1}{2}$-inch to 2 inches thick. In the open air this compressed cotton burns intensely, but without explosion; but when properly exploded under close confinement, its strength is from 2 to 5 times that of the same weight of gun-powder. If accidentally wetted, this form of gun-cotton can be re-dried by exposure to the sun, or even by a gentle heat, without risk of explosion or deterioration.

Petroleum Production.—A review of the status of the petroleum trade, according to a cotemporary, furnishes the fact that at the close of the year 1870 there were in the Pennsylvania oil region about three thousand productive wells. The production of the United States and Canada during the year is estimated to have

reached the enormous figure of six million five hundred thousand barrels, an increase of two millions of barrels over the product of 1869.

Casting under Pressure.—The casting of car wheels under pressure, according to a recent patent, has for some time been in progress at the Fairhaven (Mass.) Iron Works. It is claimed that the product is more compact, homogeneous, and free from air bubbles.

A New School of Mechanical Engineering.—Many of our readers will be interested to learn that the want so long felt in this country, of a means of thorough scientific training for those intending to pursue the profession of the mechanical engineer, is at last supplied in a very thorough manner. Among our advertisements will be found that of the Stevens Institute of Technology, which will open its first session on the 20th of next month.

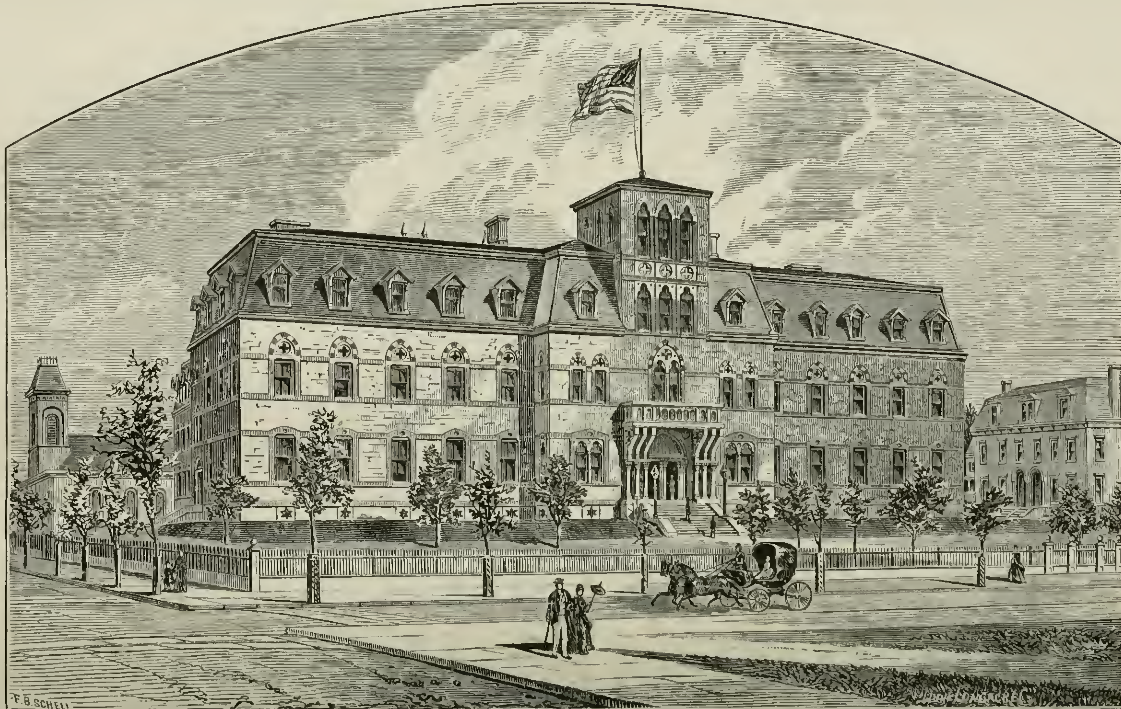
This institution, with an aggregate endowment (including accrued interest) of $750,000, a Faculty consisting of a President and seven Professors, and laboratories, cabinets of instruments and models of machinery, as well as workshops supplied with machine tools, and every other appliance of instruction, in a condition of completeness without a parallel in this country or abroad, affords an opportunity to the student of Mechanical Engineering to render himself thoroughly acquainted with the science and practice of his profession, such as will no doubt before long produce a marked impression on this and the countless dependent branches of industry.

We give herewith a front view of the Institute building, and in subsequent numbers will publish some accounts of its arrangements and collections, which involve much of novelty and interest.

Patent Law Reform.—There is herewith presented a copy of a series of resolutions upon the proposed changes in the British Patent Law. Most of the resolutions, we believe, will meet with the hearty concurrence of all having business in connection with patents; while the reforms, if made, will certainly not lessen the contrast between the thoroughness and convenience of the British Patent system and the imperfection of our own.

At a meeting of the London Patent Agents, held on the 4th inst., to consider the proposed changes in the patent laws, George Haseltine, M. A., in the chair, the following resolutions were adopted:

First—That the chief defects of the patent laws have arisen from a want of appreciation of the *natural* rights of inventors to the sole



FRONT VIEW.

use of their inventions, an unreserved recognition of which rights must pervade every equitable patent system, and the true aim of patent legislation is to harmonise these individual rights with the material interests of the state.

Second—That the grant of patents to mere "*first importers*" is an injustice to inventors, an injury to society, as it induces the "pirating" of inventions, and the reason for these grants no longer existing, legislation should confine the issue of patents to actual inventors and their representatives.

Third—That, in view of the benefits inventors confer on the public, and the expenses incident to the completion and introduction of new inventions, a patent for fourteen years is an inadequate compensation, and we deem it expedient to grant patents for a period of twenty-one years without the privilege of extension.

Fourth—That the patent laws impose *penalties* upon inventors in the form of excessive fees, which justice and public policy demand should be reduced to the amount requisite to defray the expenses of an efficient administration of a simple patent system, and fees of ten pounds for the entire term—now one hundred and seventy-five pounds—would yield more than sufficient for the purpose.

Fifth—That the defects of the present practice should be remedied by the adoption of equitable "regulations," and the introduction of the system of granting patents, at the risk of the applicants, without any official supervision of the specification or preliminary investigation of the merits of the invention.

Sixth—That the rights of patentees should be determined by a competent tribunal, excluding all technical objections to the validity of the patent, and we deem it expedient to dispense with jurors and "scientific experts" in patent suits.

Seventh—That these resolutions, signed by the Chairman, be forwarded to the Parliamentary "Select Committee on Letters Patent," and such other publicity be given them as he may deem conducive to the success of a liberal measure of patent legislation.

Crystallization of Carbonate of Lime.—It is well known that the carbonate of lime occurs in nature in two distinct crystalline forms, or two distinct mineral species, which are known as Calcite and Aragonite. The researches of Rose, published some years ago, proved that the temperature at which the carbonate was deposited from solution, affected the character of the product—the Calcite form being deposited from cold, and the Aragonite from hot

solution. A recent investigation by H. Credner has, it seems, added considerably to the list of causes which may produce this difference. As his experiments explain themselves, we will merely state his results.

A pure, cold solution of the double carbonate of lime deposits Calcite; the addition of some silicate of potassa produced the same product (as did also silicate of soda and a mixture of the two silicates), the crystals being of great clearness, and rich in surfaces. A solution of the carbonate of lime and some strontia, when made together in carbonic acid, deposited without exception the prismatic Aragonite; where the strontia solution was brought into that of the lime, rhombohedral crystals of the Calcite made their appearance along with the Aragonite, and the formation of Calcite increased as the quantity of the strontia was diminished.

An addition of Gypsum (sulphate of lime) to the lime solution, gave rise to the production of Aragonite. Additions of salts of lead produce the same result, though subject to the same regular variation as in the case of the presence of strontia.

The results of these experiments are of the greatest importance to the mineralogist, for they prove that one and the same substance can be made to originate entirely different mineral species through the impulse derived by certain foreign additions to its solutions; and also that the state of saturation and the temperature of the deposition are not the only causes of dimorphism.

We gain an insight, too, by these interesting results into the probable cause of the frequent association of the minerals in question with others. For example, the frequent association of Calcite with minerals rich in alkaline silicate, as with Apophyllite and other Zeolites, and of Aragonite with Gypsum.

Origin of Hail.—Prof. Reinsch* announces that it is impossible, in the present state of our knowledge, to proclaim a theory which shall satisfactorily explain the origin of this meteorological phenomenon.

Though it may be safely asserted that the conditions originating it are different from those producing the deposition of rain or snow, or that these conditions are more intense in character, yet a microscopic examination of hail proves that the conditions originating it are by no means always the same; for the structure of the product is rarely the same. He mentions the curious fact that in some

* Pogg. Ann., CCXVIII, 623.

hail which he examined beneath the microscope, there was found at the centres of the stones a spherical globule, which proved to be air. When these globule were nearly freed by the melting of their icy confinements, they burst the last portions of the shell with energy, and, expanding, occupied in a bubble form a space more than fifty times greater than when confined; showing that they had been subject to a pressure equivalent to more than fifty atmospheres. Cold may possibly have had some part in this diminution of volume; but the temperature necessary to produce so great a reduction in volume must have reached—214° C. at the point where the hail was formed—if cold had been the only cause in play. Whatever explanation we assign to this interesting observation, it must certainly be regarded as the most unexpected one which has yet appeared in the study of this puzzling phenomenon. Prof. R. recommends the diligent use of the microscope as the only means of solving the problem of the history of hail.

Announcement of the Prussian Association, for the promotion of Industry, at Berlin.—The programme of the Society which has appeared contains the following announcement, which may prove of interest.

The gold medal of the Association, or the money value thereof, and in addition the sum of $750, will be given to the author who gives a reliable and readily executed method of determining the quantity, as well as the various compounds met with in commercial aniline (aniline oil), and who determines also the influence which the diversity of these compounds exerts upon the manufacture and upon the yield of fuchsine. It is also desired that an investigation should be made into the conditions under which aniline yields the greatest quantity of coloring matter. The silver medal, or money value thereof, and in addition $215, is offered for the best preparation of an opaque enamel on gold, silver, copper or bronze. A donation of $187 to the author of the most critical essay on Cements in their relation to the wants of Industry. And, amongst other donations, their silver medal, or its money value, and $375, to the inventor of a yellow-colored solder which possesses the qualities of ordinary tinman's solder, by which brass and similar alloys may be united without allowing the joints to be visible.

A Barometer without Mercury.—A Heller has recently published a description of an instrument of this kind, in which the principle of the communicating tube is avoided, and the same result

is reached by ascertaining by a simple process the specific gravity of the air, and calculating from this the pressure at any given time and place.

The instrument consists of a balance-beam, with two equal weights screwed to its ends; these weights differ in volume, one of them being a hollow globe; the other a solid cylinder. At one end of the beam, and attached perpendicular to its axis, is a mirror; and at a little distance from this is fixed a telescope with vertical scale. On looking into the telescope, the image of the scale is seen on the mirror. Any variation in the pressure of the air will cause the balance to tilt, and the angle through which the beam has moved is readily determined. The oscillations of the beam for ordinary variations of pressure will be very small, but by the plan of reading the oscillations with the mirrors, a much greater precision is obtained than is possible by reading from the mercurial barometer.

By calculation, it appears, according to the author, that for 1 millimetre difference in the level of the mercury column, the beam end will move through a vertical distance on the scale of from 4 to 5 millimetres. In addition to the greater precision in reading small oscillations, other advantages are claimed.

In the ordinary barometer a large weight of mercury must be moved, implying a considerable friction against the walls of the tube, which must be overcome; if the variations of pressure are rapid, the inertia of the metal will not permit it to follow them with sufficient promptness to indicate with accuracy the maximum and minimum pressures. The influence of the slight quantity of mercury vapor always present above the column on the capillary depression, and the action of the included air, which increases with time, are beyond calculation and beyond remedy.

The ordinary barometer, again, presupposes a liquid, the specific gravity of which is accurately known. This is, however, not the case; for chemically pure mercury is difficult to obtain, and when obtained it rapidly changes by partial oxidation, thus materially affecting both the adhesion and capillary depression.

These, and analogous imperfections, which appear to be inseparable from the mercury barometer, the balance barometer does not seem to possess.

Fossiliferous Granite.—M. Reinsch, inspector of mines at Gotha, states that he has recognized microscopic organic remains, both animal and vegetable, in certain granite rocks which have hereto-

fore been reputed to be of igneous or eruptive nature; and Dr. Müller mentions a phenomena which has some analogy with the preceding, viz: the existence of living creatures in the waters of the geysers of California at a temperature of 202° Fahrenheit.

Quiet Ebullition of Liquids.—It is of great importance in many analytical and technical processes that the liquids with which one is operating should boil quietly and with regularity, without that fitfulness and bumping with which all are familiar. It is in this connection that attention is directed to a communication of Th. Schumann,* according to which this object may be accomplished in most cases by the following method:

A glass tube about $\frac{1}{8}$-inch in diameter is taken; this is melted shut at one end, and bent into the form of a hook, while the other end is left open. The tube, which should be about an inch shorter than the distance from the stopper to the bottom of the retort, is then hung by a string from the tubulure. As the liquid is heated, the air in the tube expanding gives rise to bubbles, which regularly ascend; and when the boiling point is reached, vapor of the tension of the atmosphere is formed at the open end of the tube, and the process of ebullition is carried on for days with regularity and quietness. When an operation is interrupted, or the retort filled with fresh material, it is necessary to remove the tube from the liquid, and then to introduce it afresh.

C. Winkelhofer † recommends for the same object that an artificial generation of gas should be kept up in the liquid during the operation, which he accomplishes by passing a galvanic current through it. The action of one of Bunsen's Elements, of ordinary size, is said to be sufficient for the purpose, the wires being of copper or of platinum, as the nature of the boiling liquid may require. It is plain, however, that this plan can have but a limited application in practice.

Pharaoh's Serpents.—These, once so largely popular toys, have been almost entirely abandoned, owing to the poisonous character of their constituents and of their fumes. Dr. Puscher now announces that a mixture of 2 parts of bichromate of potassa, 1 part of nitrate of potassa and 3 parts of white sugar will produce the effect of the serpents without the attendant inconveniences. He

* Am. Jour. Pharm., XLI, 527.

† Dingler's Polytech. Jour., CXCIII, 80.

recommends the mixture to be done up in paper or tin-foil cones, and also the addition of some Balsam of Peru to perfume it.

A New Experiment.—The action of Dilute Sulphuric Acid on starch is very neatly illustrated in a new experiment suggested by A. Vogel. It is well known that writing paper is so largely sized with starch that an iodine solution applied upon its surface will produce a blue color. Vogel traces first upon the paper some writing or figures with dilute sulphuric acid. The paper is then gently heated, but not sufficiently to char it. If now the iodine solution is applied, portions of the paper treated with the acid remain white, while the rest is blued. The same paper will serve repeatedly for the experiment, for the blue color gradually disappears.

Reagents for Ozone.—Lamy* has published some results of experiments upon the reliability of Ozonoscopic papers, which he has tested upon an extended scale and in a variety of situations. He announces that paper moistened with the oxide of thallium, when freshly prepared, is far more sensitive towards Ozone than that prepared with iodide of potassium and starch. The sensitiveness of this reagent (thallium oxide) depends upon the strength of the solution, and upon the extent to which the oxide has absorbed carbonic acid. Where a rapid and reliable test for the presence of Ozone in an atmosphere is desired, the thallium paper is recommended as preferable to the other, though it is not adapted for determining the quantity of this substance.

A Spontaneous Explosive.—Some experiments recently conducted at the Philadelphia High School developed the fact that when a strong solution of phosphorous in bisulphide of carbon is poured upon finely powdered chlorate of potassa resting on paper, and the mixture exposed to air, upon the evaporation of the bisulphide of carbon, the phosphorous being left in a very finely divided state, intimately mixed with the chlorate of potassa, the mixture presently explodes spontaneously, with a loud detonation. The explosion in this instance is analogous to the case of phosphorous and chlorate of potassa when struck or rubbed together, the mixture of the two substances in the present case being, however, much more perfect than can be obtained by any mechanical means. E. T.

Estimation of Chloral Hydrate.†—It is well known that the value of chloral hydrate is determined by the action of caustic

* Bullet. de la Soc. Chim. de Paris.

† Zeit. für Chemie., 1871, p. 66.

alkali upon it, and C. Muller proposes the following method of making the estimation : A glass tube graduated from the closed end upward into $\frac{1}{10}$ cc, is filled with 25 grs. chloral hydrate, and then a slight excess of caustic alkali is added, and the tube is closed with a cork. At the end of some hours, the liquid in the tube is divided into two portions of different gravities, the line of separation being clearly and sharply defined. It is only necessary to read off the number cc. of chloroform, which has been formed by the action of the alkali upon the chloral hydrate, then multiply by its specific gravity (allowance being made for the temperature), in order, by a simple calculation, to find what per cent. of chloroform has been formed. A. R. L.

Action of Water upon Iron and of Hydrogen upon Ferric Oxide.—There is a very striking and important article upon this subject, by H. St. Claire Deville, in the *Comptes Rendus*, LXX, 1105. The iron to be operated upon was placed in a boat of platinum, and this again in a porcelain tube. To maintain the iron at constant temperatures various devices were resorted to. For those below 300° C. an oil or mercury bath was used, which was heated by a gas flame regulated by Schloesing's apparatus. The constant temperature of 860° was obtained from cadmium vapor, and of 1040° through zinc vapor. The zinc is placed in a black-lead crucible such as is employed in the manufacture of steel, and containing about 20 kilogrammes of the metal. Two holes are bored through the sides of the crucible, through which an earthen tube is passed, and through this again one of porcelain. The distilled zinc is condensed by a suitable apparatus. For temperatures above 1040° the porcelain tube is heated directly in the flame of an oil lamp. The brass stop-cocks by which the porcelain tube is terminated are made double, so that a stream of water circulates through them, and prevents the destruction of the connections. One cock is connected with a retort containing water, the other communicates with a reservoir of hydrogen and with a Geissler or Sprengel pump.

In this way, Deville treated pure iron with steam at known tension and temperatures. The temperature during each experiment was maintained constant, but was varied during the course of all the experiments from 150° to 1600°. He thus obtained the following remarkable result—that if any weight of iron be subjected at a certain temperature to the action of steam, the iron is oxidized until the tension of the liberated gas rises to a certain point which

is unalterable for that temperature. This tension amounts to a very small fraction of the barometric pressure.

Since the tension does not depend at all upon the quantity of iron, the hypothesis of Berthollet, known as the Influence of Mass upon Chemical Affinity, does not by any means appear to explain the phenomena. Indeed, these experiments go to show that this hypothesis should be rejected as untrue.

When the highest pressure of steam in the apparatus, which corresponds to a certain temperature and pressure, is attained, and a certain amount of hydrogen is removed, the tension, which has undergone a momentary alteration, returns to its normal point, by the decomposition of a fresh quantity of water evaporated from the retort connected with the apparatus. If hydrogen is added, so as for a moment to increase the tension, it diminishes gradually again, while a certain quantity of ferric oxide is reduced, and water forms, which is condensed in the retort.

It follows that the hydrogen which is liberated in contact with iron, acts in accordance with the same law of hygrometry as is true in the case of steam, *i. e.* in a variable space maintained at a constant temperature, steam evaporates or condenses until the space is saturated with vapor. A. R. L.

Color Changes produced by Heat.—In our March issue, attention was called to the remarkable property of changing color possessed by certain newly discovered iodides of mercury, copper and silver, upon the application of moderate heat. Since the publication of the notice, Prof. Edwin J. Houston* has succeeded in detecting the law which underlies this curious phenomenon, and has also discovered that nearly all metallic compounds, to a greater or less degree, possess the same property: a discovery as important as it is interesting.

The Psychic Force.—In an article entitled "Experimental Investigation of a new Force," Dr. William Crookes,† F. R. S., details a number of experiments conducted by himself in company with other widely known scientific men, with a view of testing the reality of certain phenomena which have, for reasons too well known to need repetition in this place, received but little attention from men of science. The phenomena in question are, from some ridiculous theory

* On the Change in Color produced in certain Chemical Compounds by Heat. *This Journal*, LXII, 115.

† From advanced sheets of the *Quarterly Jour. Sci.*, July, 1871.

as to their origin, termed "spiritual"—a name scarcely calculated to inspire an investigator with confidence in the genuineness of the manifestations, nor to invite examination. The only published attempt to apply to them the analytical methods which are found of such service in investigating natural phenomena, is that of Tyndall (Fragments of Science, Chap. Science and Spirits), and the record of his experience is not of a character to strengthen the desire to investigate this subject. The investigations of Crookes, however, the main features of which are now about to be presented, led their author to a different conclusion; the results of his experimental tests being the announcement of the existence of a new force, in some unknown manner connected with the human organization. To this force he applies the name of the Psychic Force. The experiments were conducted upon Daniel Dunglas Home, one of those persons known as "mediums," upon the theory formerly alluded to.

Among the curious phenomena which occurred under his influence, we are informed, were the increase in weight of bodies, and the playing upon musical instruments, without direct human intervention, under conditions rendering contact or connection with the keys impossible. The conditions under which these curious results were obtained are fully and clearly stated.

The detail of the experiments are too extended to be more than briefly noticed, and this notice will be confined to that of the increase in weight, which is the most unexpected. The apparatus consisted of a mahogany board, 36 inches long by 9½ inches wide, and 1 inch thick. One end of this rested on a firm table, while the other end was supported by a spring balance, hanging from a substantial tripod stand. An automatic register was attached to the balance, which recorded the maximum weight indicated by the pointer. The board was horizontal, and the index before the experiment indicated a pressure of 3 pounds. The fingers of the actor, we are informed, were placed lightly on the extreme end of the board, which rested on the support, and the points of the balance immediately descended; it shortly rose again. This movement was repeated several times, as if caused by a succession of waves.

The extreme depression of the index indicated 9 pounds, a maximum pull of 6 pounds. The weight of one of the party, 140 pounds, applied to the place where the fingers of the actor had been, sunk the index but 1½ pounds.

These are the facts of the case as stated by the author, and the

article will be read with interest by all who desire to see brought to the light whatever of truth there may be enveloped in a monstrous tissue of fraud and deception, whether we are disposed to admit or to deny the explanation he offers of a new force—the Psychic force—to account for his results.

Behavior of Lithium Minerals in the Spectroscope.*—In the course of an investigation by von Kobell, of various minerals containing lithium, he made the curious observation that when such minerals color the flame red, it by no means follows that they exhibit the red lithium line in the spectroscope. This is not always the case, but appears to depend upon the construction of the instrument, whilst one shows the lithium line the other does not. Von Kobell's instrument, for example, in the case of an Asbolan and Psilomelane, showed the line only when the piece under examination was moistened with hydrochloric acid. The Cookeite, from Hebron, the Lithionite, from Paris, Me., showed the lithium line without aid, although the flame was merely colored yellow. The lithionites, from Zinnwald and Altenberg, on the contrary, do not show the line directly, and yet color the flame red. But all the lithionites do show the line when some fragments are melted, the glass rubbed to powder and moistened with hydrochloric acid before being brought into the flame. A. R. L.

Horse-Power of Steam Boilers.—Under its appropriate heading there is published the report of the Institute Committee, appointed to examine this question, and to fix, if possible, some uniform plan or principle which will prove acceptable to all parties in rating steam-boilers. As will be perceived upon inspection the report is but preliminary to a more complete and final one, which the committee hopes to be able to present to the Institute at no distant day.

The conflicting nature of the testimony of boiler-makers and others on some practical points, has made it necessary for the committee to extend its inquiries over as wide a field as possible, and to invite all who are interested in the acceptable solution of this interesting practical question to furnish it with the results of their experience to aid in securing a report which shall possess the largest claims for support.

* Jour. für Prakt. Chem. 1871, p. 176.

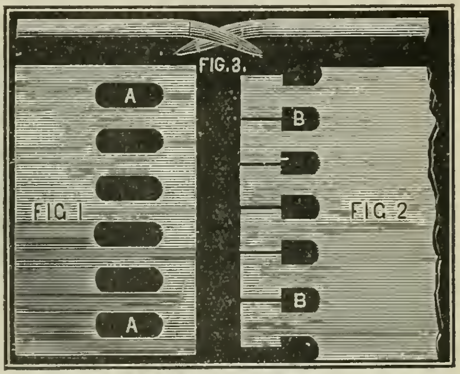
Civil and Mechanical Engineering.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 39.)

Connecting the ends of belts.—"Two or more oval slots, A A, Fig. 1, are made near one end of the belt to be joined, and in the other end, Fig. 2, of the same belt, D-shaped slots, B B, are made, the material being cut through from the middle of the straight side of the D, by an incision parallel to the length of the belt, thus dividing the end into T-shaped parts.



"The ends of the belt are scarfed, so that when engaged, they will lie closely to the body of the belt.

"In connecting the ends of the belt, the T-shaped parts are twisted quarter-way round and passed through the oval slots in the other end, and then straightened up again, thus locking the ends without the aid of laces, metal clips or buckles."—*Howarth. Mech. Mag. London,* XCIV., 289.

From C. F. Scholl's Mechanic's Guide, page 483, 4 *&* 5, *we take the following:*

"Pulleys must be true and concentric, and their shafts parallel, otherwise belts which run upon them must be guided, and the guiding device will wear their edges rapidly. To prevent belts from running off, pulleys should be made convex on their faces, much convexity, however, is destructive to thick and to double belts.—Pulleys for shifting belts should be parallel-faced, except where the shafts are far apart, when they may be convex. Flanges to pulleys and belt guides should be avoided, except to pulleys on upright shafts which have a slower motion, and where two belts run closely on the same pulley, or on two pulleys of like size; but for high speed they may be discarded.

"The softer woods are better for pulleys than the harder kinds,

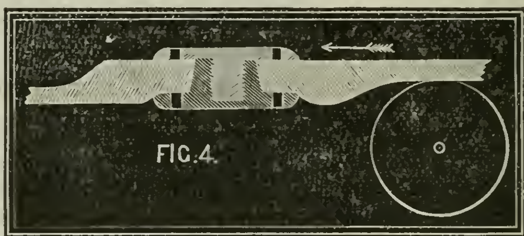
but pear wood and nut-tree are best for cord wheels. Grease must not be put on wooden wheels on which belts run.

"Tighteners must be applied to the slack side of belts.

"Good oak-tanned wild leather is the best for belts, and not that prepared with alum.

"The belts should be cut from the centre of the skin, stretched, and of even thickness throughout. The ends are joined by leather laces, rove through uniformly punched holes.

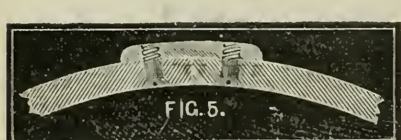
"New belts are liable to stretch, and should be unlaced, shortened, new holes punched and then laced again.

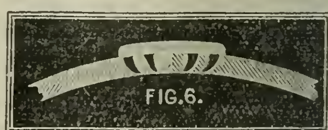


"The most practical method of fastening the ends of belts, is by the screws shown in Fig. 4. The belt must travel in the direction of the arrow, and never allowed to run against the joint.

"The method shown in Fig. 5 is also recommended. The plate is of brass, rather narrower than the belt, curved to the pulley, lapping the joint, and receives countersunk head screws from each end of the belt.

"In Fig. 6 another plan is shown in which incurved teeth of malleable iron connected to a plate, are driven through each end of the belt when butted, and are then clinched on the inside.





"Thickness of belt does not always give strength. Small pulleys injure the structure of the belt by too great flexure. Single belts are relatively more durable than compound belts, the latter should be used only on large diameter of pulleys. Gum belts and belts of

which gum forms a part, are preferable in damp localities, but they should not be shifted much.

Horizontal running belts should be long; their own weight doing the required work without excessive tension, but is limited to a shaft distance of about 28 feet. At a greater distance than this, especially at high speeds, belts sway injuriously from side to side.

"Powdered Colophonium may be applied to a slipping belt.

"Belts driving mills at high speed, work better than toothed wheels, and all machines subject to intermittent motions, or liable to sudden stoppage, should be driven by belts.

"Fat should be applied to belts, say every three months of their use: they should first be washed with luke-warm water, and then have leather grease well rubbed in.

"A good composition which should be applied warm, consists of:—

Lard or Tallow	1 part.
Fish Oil	4 "
Colophonium	1 "
Wood Tar	1 "

(To be continued.)

PRELIMINARY REPORT OF THE COMMITTEE APPOINTED TO EXAMINE INTO THE MODES OF DETERMINING THE HORSE-POWER OF STEAM-BOILERS.

At the stated meeting of the Institute, held June 21st, the following partial report of its labors was presented by the chairman of the committee:—

The committee to which was referred the consideration of some definite rule for determining the horse-power of steam-boilers, beg leave to report as follows:—

In a thorough examination of this question, it is necessary first to advert to the origin of the term horse-power, and the manner in which it was first used to designate the power of the steam-engine.

The early demand for the steam-engine was to effect some task before performed by horses, and it became a question of comparison of the new mechanical with the animal motor.

From experiments made to determine the actual power exerted by good average horses, it has been found that a horse working for 8 hours per day, will exert a force equal to about 23,400 lbs., and

when working for 3 hours only, will exert as much as 32,900 lbs. raised one foot high per minute.—(See Ure's Dictionary.)

The example taken as a unit by James Watt, was that given by the heavy dray horses of the brewers of London, whose maximum performance in hauling was found to be 150 lbs. at $2\frac{1}{2}$ miles per hour; equal to 33,000 pounds lifted one foot high in a minute.

This has since remained the standard for a horse-power both in the English, Continental and American practice.

This unit of power exerted upon the piston of the steam-engine, measured by the instrument known as an indicator, is termed the indicated horse-power; and the power given out by the engine to the machinery is the actual or effective horse-power, being the indicated power minus the friction of the engine.

There is, also, the nominal power, a term based upon the size of the cylinder and arbitrarily assumed speed of piston and pressure of steam. This might also be termed the commercial power of the engine.

Watt, in the construction of steam-engines after the type established by him, adopted for the speed of the piston 128 times the cube root of the stroke in feet; and assumed 7 lbs. as the effective pressure upon the piston.

He thus obtained a nominal horse-power which, under the most unfavorable circumstances, his engines were sure to produce.

Then, again, we have the rule of the British Admiralty for marine engines, in which the old assumed pressure of 7 lbs. is adhered to, but the *actual* speed of the piston is taken into account.

Another rule for the nominal power of high pressure engines has the authority of Bourne, who assumes the speed of the piston to be that given by Watt, and the effective pressure on the piston to be three times as great, *i. e.*, 21 lbs. per square inch.

His rule is, multiply the square of the diameter of the cylinder in inches, by the cube root of the stroke in feet, and divide the product by $15\frac{3}{5}$. Thus we find a great diversity in the rules for estimating the nominal power of engines. This nominal power, the power at which the engine is rated by the maker, has gradually become greater as the speed and pressure have been increased.

But in *all cases* the nominal power is *much less* than the actual power at which such engine is capable of working with the average pressure and speed common to engines of that class.

Going back to the historical era of the use of steam, the com-

mittee find that at an early day, although subsequent to Watt's time, the evaporation of a cubic foot of water per hour, from and at the temperature of 212°, was ruled to be the measure of a nominal horse-power.

All subsequent authorities, without exception, have adopted this standard;—in the *steam boiler* they make no distinction between the nominal and actual horse-power; there is only one definition of the term, and that is the evaporation of a cubic foot of water as previously stated. It is with this definition that we use the term horse-power.

This rule appears yet to be applicable, and it only needs some statements of conditions, such as will allow purchasers and sellers to conform to this requirement.

For stationary boilers with natural draft, assuming that the chimneys and flues shall be adequate in size and form, to afford the necessary draft, and that the fuel is coal of average good quality, it appears that nearly all writers give about $\frac{55}{100}$ square foot of grate to each horse-power of boilers, and as this ratio gives a very small grate for the lesser number of horse-power, about 2 feet are added as a constant.

Having thus designated the means for burning the fuel, the conditions attached to the horse-power of boilers are within some limit as to quantity of fuel to be used in producing this effect.

In other words, the arrangement and extent of heating surface should be such that at least the average result by evaporation of 9 lbs. of water from and at 212° with one pound of good anthracite coal burned (over and above ashes) shall be attained.

As there are 59·48 pound of water at 212° in a cubic foot, it follows that 6·61 pounds of coal will be needed for its evaporation.

Adopting the more convenient number of 7 lbs. as a liberal allowance, the rule would be $\frac{7 \text{ H. P.}}{0{\cdot}55 \text{ H. P.} + 2}$ = the number of pounds burned per hour per square foot of grate; or for boilers of—

10	H. P.	$7\frac{1}{2}$	square	ft. of	grate	9·33	lbs. per hour	per sq. ft.	of grate.
20	"	13	"	"	"	10·76	"	"	"
40	"	24	"	"	"	11·66	"	"	"
60	"	35	"	"	"	12·00	"	"	"

It may be as well to refer to chimneys and flues, and add that the average heights of chimneys above the surface of the grate, for

stationary boilers, should be taken as from 50 to 60 feet, and the sectional area to conform to Boulton and Watt's rule (as quoted by Bourne,) which is,—"Multiply the number of pounds of coal consumed under the boiler per hour by 12, and divide the product by the square root of the height of the chimney in feet, and the quotient is the proper area of the chimney in inches at the smallest part."

"The rule, though appropriate for land boilers of moderate size, is not applicable to powerful boilers with internal flues, such as those used in steam vessels in which the sectional area of the chimney is from 6 to 8 square inches per horse-power."

The sectional area of tubes or flues, and the setting of the boiler must also be properly proportioned, so that the escaping gases, as they leave the steam generating surface, be not more than 300° above the temperature of the steam.

The above conditions apply particularly to stationary boilers, with natural draft.

We have no intention, however, to limit the test of a boiler to these conditions of grate surface and chimney, they are incidentally mentioned as good average practice.

When a forced draft is employed, as in the locomotive, we find the heating surface 65 times the grate area, and 80 lbs. of coal burnt per square foot of grate.

These general conditions, dependent upon each other being fulfilled, viz., a grate surface so proportioned to the draft as to admit easily the combustion of 7 lbs. of anthracite coal, or combustible equal to that amount per horse-power per hour, and the escaping gases not over the temperature before mentioned; it may be safely asserted that a boiler so set, of any given horse-power, failing to evaporate that number of cubic feet of water per hour, with that amount of coal, does not produce its nominal horse-power.

We may also state, in connection herewith, that a cubic foot of water evaporated into steam, is abundance for one actual horse-power when used in the cylinder of an engine without expansion: when used in a three port slide-valve engine, cutting off during the last quarter, it will yield about $1\frac{1}{3}$ indicated horse-power; and will give as high as $2\frac{1}{2}$ indicated horse-power, according to the pressure of the steam, the point of cut-off and the type and efficiency of the engine.

In usual practice, the feed-water will be admitted to the boiler at temperatures varying from 40° to 200°.

To make the proper correction for 212°, and to ascertain the quantity of water which would have been evaporated had the feed-water been at 212°, we give the following rule:

The latent heat of steam being 966° and T the temperature of feed-water.

As 966 : (1178°—T) :: water evaporated : water evaporated at 212°.

It may be more satisfactory sometimes to ascertain the evaporative duty of a boiler, in connection with the horse-power developed from that amount of steam passed through the engine; in which case the formula immediately preceding will be varied, so as to substitute the temperature of the steam (latent and sensible) at the pressure used, for the figures 1178°.

The total temperature of steam for the pressure used may be taken from the table in Bournes' hand-book, page 159.

In order to reduce the evaporative effect of a boiler with different temperatures of feed-water, and of steam produced, to its equivalent evaporation of water from 212° to steam at 212°, the following formula is useful:

Let E = number of feet or pounds evaporated at 212° in a given time.

E 212° = number of feet or pounds evaporated under conditions taken.

T_w = temperature of water fed into the boiler.

T_s = temperature of steam formed in boiler.

$$E\,212^\circ = E\left(\frac{1114 + 0{\cdot}305\,T_s - T_w}{966}\right).$$

The amount of water carried over mechanically with the steam, is a feature which must not be overlooked, and the amount determined by one of the available methods.

The conditions of cleanliness of the external and internal surfaces of the boiler, and the maintenance of such cleanliness, cannot well be defined, but it is obvious that such conditions are essential in practice, and that no boiler without provision made for these purposes, and also for an efficient circulation can be a complete success.

There are several well-known types of boilers such as the plain cylinder, the horizontal flue and horizontal and upright tubular; the horse-power of which estimated by the heating surface could easily be established from a series of actual experiments, and a certain

minimum amount of heating surface laid down as a rule for practice.

It is quite obvious that one of these, the plain cylinder for example, might be so badly set, or unskillfully fired, that the evaporative duty would be much reduced below the actual standard to which the boiler is entitled,

This deficiency could not be said to result from error of form or construction of the boiler.

Exceptional cases will sometimes occur in no way modifying the general rule herein laid down, viz: that the rating shall be ascertained under what is acknowledged by engineers as good conditions of practice. Were it otherwise, we should see a small boiler giving out its nominal power merely by an intense fire and red-hot chimney.

Much uncertainty in the purchase and sale of boilers would be obviated, if the horse-power were specified in connection with the pounds of combustible to be used per horse-power, (*i. e.*, per cubic foot of water evaporated) per hour.

So, also, the term horse-power when used in reference to steam-engines, would be better qualified by the words nominal, indicated or actual.

With all this variety of requirement it is safe to conclude that the old practice and definition of a nominal horse-power, gives ample protection to the sellers and buyers of boilers, when the conditions long ago established and herein stated are admitted.

Your Committee refer to the following as original authorities: Smeaton's Reports; James Watt Annotations to Dr. Robinson in the Encyclopædia; Farey on the Steam-Engine; Tredgold Steam-Engine; Bournes' (Artizans' Club) on the Steam-Engine; Bournes' Catechism and Hand-Book; Rankine's Steam-Engine and Prime Movers; D. K. Clark Railway Machinery; Fairbairn on Mills and Mill Work; Box on Heat; Peclet Traité de la Chaleur, and other works on Heat and the Steam-Engine.

Readers, however, who desire to investigate this subject will find in Rankine's Prime Movers, Bournes' several works, especially his Hand-Book, Fairbairn on Mills and Mill Work and Box on Heat, a complete exhibition of the theory and practice of steam-boilers.

The Committee have delayed handing in this Report with the expectation of being able to fix upon some definite amount of heat-

ing surface required per horse-power for well-known types of boilers.

We find, however, that boiler makers are far from unanimous as to the amount required, neither is their estimate always made upon the basis herein laid down; nor can we find any published account of any extended experiments sufficiently accurate to warrant the insertion of them in this report.

As it is likely several months may elapse before the Committee will be in possession of sufficient facts to satisfy them on this point, they are compelled to defer this portion of their report until a future occasion.

In the meantime they make the request to any engineers who have made or may make investigations bearing on this point, (viz., the heating surface required,) to forward the full particulars to the Secretary of the Franklin Institute.

EDWARD BROWN,
ROBERT BRIGGS,
JOHN H. COOPER,
W. BARNET LE VAN,
WILLIAM H. WAHL.

Hall of Franklin Institute, June 21, 1871.

Upon the reading of the foregoing, it was resolved that the Report of the Committee be received and printed in the *Journal*, in order to bring it more directly to the notice of the members, and that the Committee be continued.

INTEROCEANIC COMMUNICATION ACROSS CENTRAL AMERICA.

By PROF. J. E. NOURSE.

ALTHOUGH the reports from the explorers on our Isthmus, who are now renewing the search for a practicable canal route, may not prove as favorable as could be desired, the great problem will lose nothing of its intrinsic interest. "The Canal must come," as Chevalier has said, in its turn. It is to be regretted that one of the two Government Expeditions now on the Isthmus has found itself in the field, each year, so late in the season in which proper work could be done. It is creditably reported of the other, the

Tehuantepec party, that it feels assured of having succeeded in its object.

As no full, yet succinct English memoir is to be found of the schemes, explorations professed or real, surveys or plans for opening up this long coveted passage, it is proposed to compile, for the Franklin Institute *Journal*, a historic memorandum, as a guide to those explorations. The writer will be able to claim at least an entire freedom from any bias toward a particular route—from all such temptations as are plainly seen to have had their force in coloring such a route when reported upon by the servants of a patriotic company. He will aim to present facts only; and to this end will gladly receive information from any of the numerous friends of the enterprise—promptly accrediting the same. There may be, on the part of companies, adventurers, and all others, a common and true desire to have the great work secured, and secured in our own day by Americans. May not the desire become a just expectancy?

The completion of the new route to the East, the Suez Canal, urges upon Americans, energetic and thorough explorations to secure a water communication across our own continent, lest Europeans entirely distance us, not only in energy and perseverance, but, in this lamentable day of the decadence of our shipping, in commercial rank. The Suez route is opening up the Indies to England and the Mediterranean cities, by voyages of but half the old required time or risk, and by commercial returns of untold wealth.

The great need in the matter of communication across our continent is, undoubtedly, a Ship Canal, if possible, without locks or tunnels, as Humboldt urges; at all events, a ship canal which will float the largest vessels of the merchant or the government marine. Through this the world's fleets should pass, without the disadvantage of being required to break bulk or employ lighters. Is the coast line and the physical geography of the interior at all favorable for such a transit? In this inquiry let us look for a moment at the marked characteristics of the GREAT AMERICAN ISTHMUS.

Central America, considered in the fullest extent to which the name is geographically applicable, well merits the title given above. Its general direction, the trending of its coast line, is from W. N. W. to E. S. E. The length of the longest line from the mouth of the Coatzacoalcos, Mexico, (N. Lat. about 18° 20′) to the mouth of the Atrato, New Grenada, (N. Lat. about 8° 15′) is estimated at about

four hundred and fifty miles. Through this extent it has been called the "gigantic causeway which separates two oceans and unites two continents." Other noted Isthmuses in the world, separating only Gulfs which penetrate the interior, or perhaps a bay from a sea, are but a fiftieth or a hundredth part of the length just named. Our Isthmus divides the two great oceans of the globe.

Throughout its extent from Mexico to the Atrato, there are several short necks of land which seem to indicate, at first sight, the lines through which water communication may be made from ocean to ocean; especially toward the southern part of the Isthmus the land narrows to be far out of proportion to its length. This extreme relative narrowness, and the direction of the river courses down the two opposite slopes toward the two oceans, have kept alive, for the last three hundred and fifty years, increasing desires for an easy and rapid crossing; desires first, in part, satisfied by the completion, in 1855, of that herculean task, the Panama Railroad.

"The facts that where the oceans approach each other on this Isthmus she has supplied harbors of unsurpassed excellence on both sides, and navigable rivers that invite the traveller to penetrate the interior, and that she has also established on the one side a tidal connection in the highest degree favorable," are enough to make loud claims upon the nations to follow her hand-pointing until they have travelled successfully through the whole short, though arduous journey that leads across.

It seems to any one who has the map under his eye, that such a water passage ought also to be of the nature of a free Strait. "In width, depth, in supply of water, in good anchorage and secure harbors at both ends, and in absolute freedom from obstruction by lifting locks, or otherwise, it ought," says Admiral Davis, "to possess this character." Such a water communication, if it naturally existed, would be claimed by the trading nations of the world as one of their great highways. Would it not be clearly the right of all nations to pass through it, as their shortest route of communication with each other? Could any plea of supposed insecurity, or "immemorial usage" on the part of a nation bordering on such a passage be admitted in bar? Would not the spirit of the age, which has put an end to one such plea on the part of Denmark, readily find here also some equitable plan of capitalizing once and forever all these claims? It would be distinctly enough intimated, by

every dictate of reason and justice, that trade must pass freely. This would be as true here as for the Straits of Gibraltar.

"If," says Wheaton, "those Straits were bordered on both sides by the possessions of the same nation, and were so narrow that they were commanded by cannon shot from both shores, this passage would not be less freely open to all nations, since the navigation of the Atlantic and the Mediterranean is free to all, and *all have the clear natural right to reach the countries beyond.*

Historic interest of the Problem.—"The problem of interoceanic communication," said Charles Sumner in the United States Senate in 1867, "has not only a practical value but an historic grandeur. From the time of Charles V, one of the aspirations of Spain and of all adventurers and navigators in those seas, for many years, has been to find what was called a gate by which to pass through the Isthmus into the other ocean." The search for it is identical with the voyages of discovery on the western coasts *from Behring's Strait to Cape Horn.*

The points in its history now brought together are chiefly from the pen of our countryman Squier; from M. Chevalier, the French statesman and scholar; Admiral Fitzroy, R. N., the late British hydrographer; and Malte Brun, Jr., of the Geographical Society of Paris. Chevalier not only thoroughly studied the subject of canalizing the Isthmus, but visited it, and more than once made vigorous movements in the interests of this question, for other ultimate purposes than the canal—for the upholding of the cause of monarchy and of the Latin race on this continent. He holds a charter for a canal across Nicaragua, dated in 1869. In an elaborate discussion in the *Revue des deux Mondes*, 1844, entitled "L'Isthme de Panama, L'Isthme de Suez," he tells the following strange but true story of the apathy and neglect of all enterprise in this matter by

The Government of Old Spain.—The thought of opening a route from Europe westward to China and Japan is no new thing. Columbus had this one aim when setting out from Spain. He afterwards supposed that he had landed on a part of the dominions of the Emperor of China, "the Grand Khan." He died believing, after four voyages, that he had indeed reached Asia. He never saw the Pacific. That honor was reserved for one of the most remarkable men of Spain, then so fruitful in heroes—Vasco Nûnes de Balboa.

We cannot recall his name without the feeling of profound sympathy as well as admiration. The New World was born indeed in

the sufferings of those who gave it European civilization. Columbus, in chains, and Cortez, at the close of life, abandoned as some obscure adventurer, and dying of grief, are the two chief figures in the picture which sheds but little honor on humanity; by their side appears also the heroic Balboa, perishing upon the gallows. Eager to secure the sanction of the Spanish Court for the position of chief in the little colony of Santa Maria, Balboa made explorations among the neighboring tribes on the Isthmus, and thus acquired the information that "an ocean lay at a distance of six days' journey, and, adjoining it, an empire abounding in gold." The natives meant by this the country of Peru. Balboa undertook to penetrate the unbroken forests and reach the mysterious sea.

On the 25th of September, 1513, he at last gazed upon the ocean from the summit of the Sierra Quaragena, which he had not permitted anyone but himself to climb. Then, falling on his knees, he gave thanks to the Almighty for having reserved for him the glory of a discovery so profitable for his country. Some days after, arriving on the coast, clad in armor, with shield and drawn sword, he breasted the waves of the Great Sea, claimed it for his sovereign, and swore to defend it for him.

The court of Spain was thrown into raptures on receiving his dispatches. The key to the treasures of the vast Indies, till then in the hands of the Portuguese, seemed now delivered up. Instantly they resolved to pursue such advantages. But the affairs of the Indies were then unhappily directed by one of those miserable creatures to whom another's fame is an insupportable burden, and whose great happiness seems to consist in torturing all noble characters to whom they see the multitudes giving their admiration and regard. Such a man was Fonseca. He had cunningly plotted against Columbus, even while he was living under the protection and bounty of Isabella. He pursued the illustrious Admiral with unsparing hate, to the injury of his heirs; and he had consummated his infamous intrigues by plotting the assassination of Cortez, solely because of his great fame. Fonseca, instead of giving the command of the expedition to Balboa, chose an obscure man, Davila, one of whose first acts was to impose a heavy fine upon Balboa for some alleged old irregularities in other districts.

When Balboa was preparing to sail down the coast to Peru, which no one had as yet reached, Davila, though previously reconciled to him, and now allied to him by marriage, suddenly caused his arrest;

condemned him by the agency of his minions, and executed him despite the entreaties of the colonists.

The existence of another ocean once established, it was still unknown whether America formed one continent or was broken into masses by any narrow arms of the sea. To determine this question there were many expeditions during the earliest part of the sixteenth century. Sebastian Cabot, in the service of England, had already visited Labrador in 1497–'98, in search of the northwest passage to India. In 1499 and 1500, the Florentine, Amerigo Vespucci, had coasted Central America from the Gulf of Darien to the shores of Venezuela and Guiana.

In 1500, one of the glorious companions of Columbus, Vincent Y. Pinzon, took possession of Cape St. Augustin, and discovered the mouth of the river of the Amazons; and one of the three Cortereals, Frenchmen remarkable for their bravery, and still more for their brotherly affection, made a voyage of discovery for the King of Portugal, as far as the mouth of the St. Lawrence. In this same year, Pedro Alvares de Cabral, by accident discovered the coast of Brazil, while on his route to the Indies by way of the Cape of Good Hope.

Popular rumor exaggerated these discoveries. Men began to think, as Voltaire afterwards said, to the honor of Columbus, that "creation was really doubled;" and, justly enough, that these new countries must be distinct and separate from India, China and Japan.

In the mean time, the great successes of the Portuguese troubled the sleep of Ferdinand and his counsellors. For the Portuguese, led by De Gama around the Cape of Good Hope, had quickly reached the populous India of Alexander the Great, a country renowned all over Europe for its pearls and spices. They had thus covered themselves with glory, and brought home a vast amount of treasure.

The Spanish discoverers, as yet, had not reached the countries either of Montezuma or of the Incas. Everything, then, of personal ambition and national pride, the thirst of gold, the zeal of religious proselytism, and the cold calculations of state policy, now concurred in the disposition to sacrifice what Spain already had, of most value on the American shores, in order to seize upon a greater good—the Indies, still supposed to be near at hand.

To reach them it was said it was only necessary to find what has ever since been called "the Secret of the Strait;" that is to say,

some arm of the sea between the new countries which would give a passage directly westward to the land of spices. In 1508, a great expedition for this purpose coasted Brazil. In 1515, Juan de Solis entered the La Plata. He was massacred by the natives, and his expedition, with others, served only to show that the east coast of America was an unbroken continent.

On their side, the Portuguese made like search. After the explorations of the Cortereals toward the north-west, Magellan, in 1517, offered his services to the court of Spain, affirming that he knew where there was a passage to the Pacific, on the south, "for," said he, "I have seen it traced on a chart by the famous Geographer of Nuremburg, Marten Behaim." This was poor authority, for how could Behaim know of such a Strait? Magellan was, however, entrusted with a squadron. He set sail, and, in fact, did enter, in October, 1520, the very Strait which bears his name, and passed through it to the Pacific.

This passage, however, served only to gain for the Spaniards Chili and Peru. It was too far off to bring any communication with India; it was dangerous; and when afterwards Cape Horn had been reached by Le Maire and Schouten, sent by the Dutch—rivals also for the land of the Strait—for a time it was abandoned by navigators.

At the very time that Magellan was entering his Straits, Cortez was conquering Mexico. During his short friendship with Montezuma, he asked him the secret of the Strait, and the possibility of finding on the Mexican shore of the Atlantic a better anchorage than Vera Cruz. According to a despatch from Cortez to Charles V, Montezuma sent, in reply, a chart, on which the Spanish pilots recognized the mouth of a great river, which Cortez sent immediately to explore. It was the Guasacoalcos. It was fully ascertained that no Strait existed there, but it seemed likely that easy communication could be made between Coatzacoalcos and Tehuantepec by means of this river and the Chimalapa. Hence, large workshops were built at Tehuantepec and Grijalvas, and expeditions were despatched thence toward California, to the same great end and purpose of discovering the Strait. The vessels in which Cortez embarked at Chametla for the same destination were built at the mouth of the Chimalapa, of materials brought by way of the Guasacoalcos.

Cortez himself, in reply to a communication from the great Charles in 1523, enjoining on him to seek most diligently for "el

Secreto del Estrecho," laments the failure of the search, but does not abandon hope that still he may discover the route which would, as was supposed, shorten by two-thirds the voyage from Cadiz to Cathay and the land of spices, and " make the King of Spain master of so many kingdoms that he might consider himself Lord of the world."

Very soon, however, the hope of finding the Strait near the Gulf of Mexico or along the Isthmus was utterly destroyed. Elsewhere the pursuit was continued by the English. Hudson and Baffin gave their names to places first visited in the search.

In the first part of the eighteenth century, the Swede, Behring, in the service of Russia, proved that the American and Asiatic continents were separated, but he miserably perished on the island that still bears his name, near the Strait that also keeps it.

NOTE —A new interest in Behring's search for the route is awakened by the transfer to the United States of the lands to which, in 1785, he led the way for Russia.

" Russia, shut up in a distant interior, and struggling with barbarism, was scarcely known to the other Powers at the time they were lifting their flags in the western hemisphere. At a later day the same powerful genius which made her known as an empire set in motion the enterprise by which these possessions were opened to her dominion. Peter the Great, himself a ship builder and a reformer, who had worked in the ship yards of England and Holland, was curious to know if Asia and America were separated by the sea, or if they constituted one undivided body with different names, like Europe and Asia. To obtain this information he wrote with his own hand the instructions, and ordered his chief admiral to see them carried into execution.

" The Czar died in the winter of 1725 ; but the Empress Catharine, faithful to the desires of her husband, did not allow this work to be neglected. Vitus Behring, a Dane by birth, and a navigator of some experience, was made commander. The place of embarkation was on the other side of the Asiatic continent. Taking with him officers and ship builders, the navigator left St. Petersburg by land Feb. 5th, 1725, and commenced the preliminary journey across Siberia, northern Asia, and the sea of Okhotsk to the coast of Kamschatka, which they reached after infinite hardships and delays, sometimes with dogs for horses, and sometimes supporting life by eating leather bags, straps, and shoes. More than three years were passed in this toilsome and perilous journey to the place of embarkation. At last, on the 20th of July, 1728, the party was able to set sail in a small vessel, called the Gabriel, and described as 'like the packet boats used in the Baltic.' Steering in a northeasterly direction, Behring passed a large island, which he called St. Lawrence, from the saint on whose day it was seen. Continuing northward, and hugging the Asiatic coast, Behring turned back only when he thought he had reached the northeastern extremity of Asia, and was satisfied that the two continents were separated from each other. He did not penetrate farther north than 67° 30′. By another dreary land journey he made his way back to St. Petersburg in March, 1730, after an absence of five years.

" Behring first saw the continent of North America on 18th July, 1741, in lati-

tude 58° 28′. Looking at it from a distance, 'the country had terrible high mountains that were covered with snow.' Two days later he anchored in a sheltered bay near a point which he called, from the saint day on which he saw it, Cape St. Elias. He was in the shadow of Mount St. Elias. * * * * * * * *

"The desire of the Russian Government to get behind the curtain increased. Behring volunteered to undertake the discoveries that remained to be made. He was created a commodore, and his old lieutenants were created captains. The Senate, the Admiralty, and the Academy of Sciences at St. Petersburg all united in the enterprise. But on his subsequent voyage he was driven, like Ulysses, on the uncertain waves. A single tempest raged for seventeen days, so that the ancient pilot, who had known the sea for fifty years, declared that he had seen nothing like it in his life. Scurvy came with its disheartening horrors. The commodore himself was a sufferer. Rigging broke. Cables snapped. Anchors were lost. At last the tempest-tossed vessel was cast upon a desert island, then without a name, where the commodore, sheltered in a ditch and half covered with sand as a protection against cold, died 8th December, 1741. His body, after his decease, was 'scraped out of the ground,' and buried on this island, which is called by his name, and constitutes an outpost of the Asiatic continent. Thus the Russian navigator, after the discovery of America, died in Asia. Russia, by the recent demarcation, does not fail to retain his last resting place among her possessions."—*Sumner's Speech on the Treaty transferring Alaska.*

(To be continued.)

ON THE SOLUTION, MAINLY BY THE AID OF GRAPHICAL CONSTRUCTION, OF A PROBLEM IN PRACTICAL HYDRAULICS.

By Clemens Herschell, C. E.

The problem to be solved was the determination of the interior cross-section, and the position, relative to the level of low water, of a sluice having self-acting tide gates at its outer end, and which was to effect the drainage of a certain area of salt marsh bordering on the tidal portion of a small river. The data were, a number of observations of tides, giving a complete spring-tide and a complete neap-tide curve for 24 hours, at the point where it was proposed to place the sluice; the area of the marsh and appurtenant water shed; the quantity of fresh water coming down the river where the marsh begins, in freshets and ordinarily; the area of the river bed; and finally, the level of the marsh relative to the levels of the different stages of the tide.

It is intended in this article to exemplify also, in a striking manner, the utility of graphical construction in the solution of problems of this kind; indeed, without the aid of such a diagram it would, perhaps, have been difficult to devise the given method of calculation.

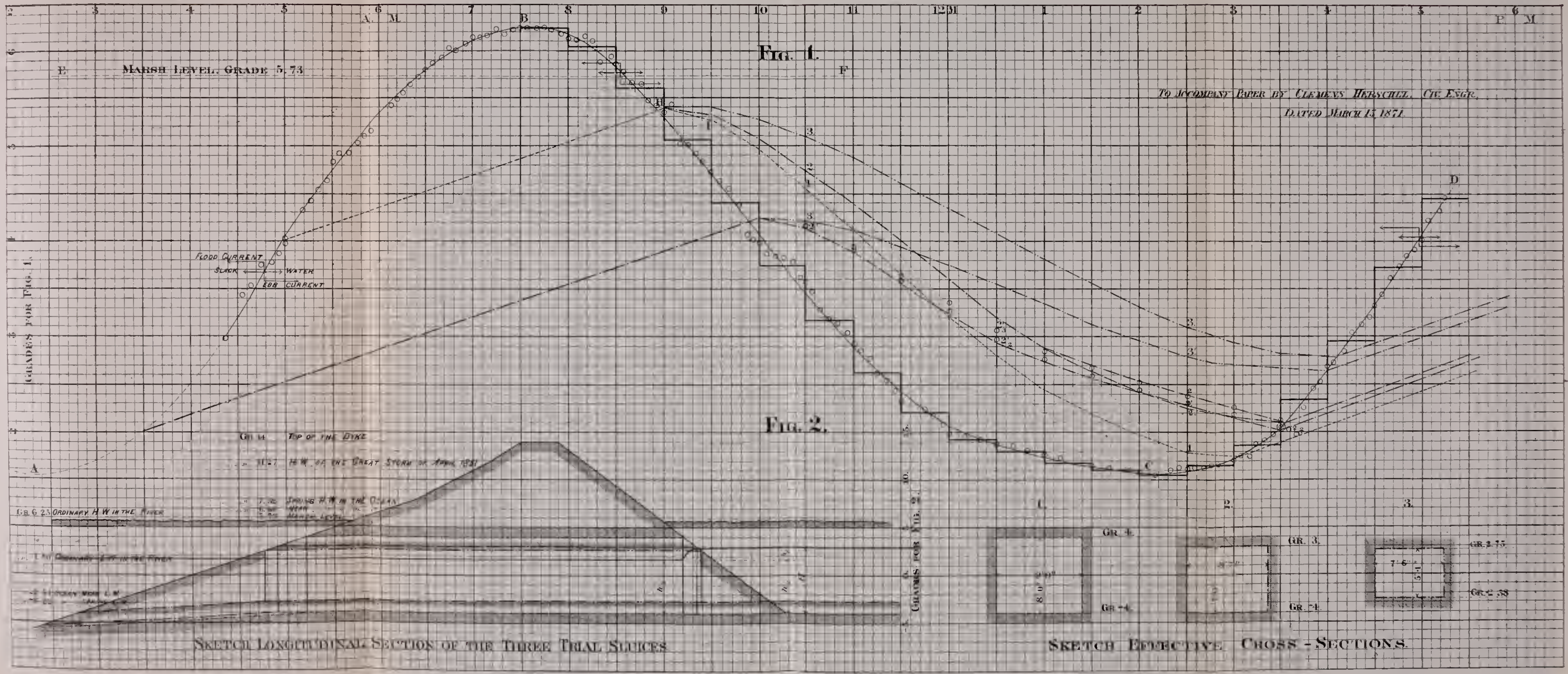
The calculations were made only for the most disadvantageous case; but, of course, there is nothing to hinder their being made for any of the possible circumstances. An inspection of the tide curves (by which is meant a plotting of the tidal observations, taking the times for abscissæ, and the observed heights for ordinates) showed that a neap tide would be most unfavorable for the drainage of the marshes, and a neap-tide curve was accordingly made the basis of the calculations. This curve is shown on the diagram, being the line A B C D, drawn as a full black line. The level of the marsh is shown by the line E F, on grade 5·73.* German authorities give as the depths below the surface to which the water must be drained, so as to enable the culture of various products, the following:

For different qualities of meadow hay,.........	1 foot to 1 foot 5 inches.
For corn and cereals....................................	2 feet 4 inches.
For orchards and nurseries,.........................	4 feet.

Let it now be supposed that the water stands in the river at a level of about 1 foot 9 inches below the marsh level, that is, on grade 4, at the time when the gates will be shut by the rising tide; in other words, the river is supposed to be nearly as full as it ever should be at the *close* of a period of drainage outflow. On the outside, the tide will then continue to rise as indicated by the curve A B C D; on the inside the water will also rise, it having no outlet —this rise depending (1) on the quantity of fresh water coming down the river at its outlet, this again being composed of the flow of the river where it enters the marsh, and on the direct drainage from the marsh and immediate surroundings; and (2) naturally, also, on the area of the basin in which the water rises, *i. e.*, the area of the river bed. The first is given us, for our most disadvantageous case, by the quantity of water flowing in the river, in freshets or ordinary high water, and was about 70 cubic feet per second.

An English rule for draining salt marsh is given thus: provide for the drainage of 0·0055 feet of rain per 24 hours over the whole area of the marsh; it seemed, however, to the writer, that in following this rule, which allows for so small a rain fall per diem, the marshes would undoubtedly be subject to overflow during heavy

* Many readers have, perhaps, felt the superior vitality, or power of interesting them, that the presence of numerical values gives to a mathematical problem; for this reason they have been introduced into this article (giving them as they entered into an actual example), instead of treating the subject generally, and using only algebraic values for the various data and results.


A. M.
P. M.
Fig. 1.
Marsh Level. Grade 5.73
To accompany Paper by Clemens Herschel, Civ. Engr.
Dated March 15, 1871.
Flood Current
Slack Water
Ebb Current
Grades for Fig. 1.
Fig. 2.
Top of the Dyke
H. W. of the Great Storm of April 1851
Ordinary H. W. in the River
Grades for Fig. 2.
Gr. 4.
Gr. -4.
Gr. 3.
Gr. 2.75
Sketch Longitudinal Section of the Three Trial Sluices
Sketch Effective Cross-Sections.

[illegible]

rain storms. In preference to this, an effective rain fall of 2 in. = ·1667 feet per 24 hours over 1500 acres was therefore provided for. The area of the river bed was found to be about two million square feet, and this figure was adopted: also, for the sake of simplicity, it was supposed that the banks of the river were vertical.

With these data—a heavy rain storm and freshet together —it will be found that the water on the inside rises

$$\frac{0{\cdot}1667 \times 43560 \times 1500}{2 \text{ million} \times 48} + \frac{70 \times 1800}{2 \text{ million}} = 0{\cdot}176 \text{ feet per half hour.}$$

This rise is represented by the straight line GH: had we taken into account the smaller area of the river bed at the lower grades, and the greater area at the higher ones, we should have had instead of a uniform rise one diminishing in height per unit of time as the water rises, that is, instead of a straight line GH, a curved one with the convex side uppermost. Where greater accuracy is required (and would be paid for), there is, of course, nothing to hinder the engineer from taking account of this, and other greater approximations, which will appear to have been neglected in the given calculations. The waters on the inside and outside coincide, as will be seen from the diagram, at 9 o'clock A. M. on grade 5·40, at which time the gates will open, or, at least, be in a state of unstable equilibrium. In order now to bring the calculation within the reach of ordinary mathematics, let us suppose that the tide rises or falls by steps, say every half hour. If we shall find that this will lead to any anomalies or defects of any serious kind, it will be easy to take a smaller space of time as the unit, until, finally, we shall get the desired regularity of results; in this case, half an hour proved to be as small an interval or differential of time as was necessary.

At 9 o'clock, then, the tide suddenly falls from grade 5·60 to grade 5·06, the water on the inside standing, as previously mentioned, on grade 5·40. We have, then, a head of 5·40 — 5·06 = 0·34 feet on the sluice for the next half hour, or, at least, we suppose that we have, in further assuming that the inside level is not appreciably altered by the outflow during the half hour. This last assumption again is slightly approximative, and could, under all the existing circumstances, best be made more nearly correct by taking a shorter interval of time as the basis of calculation.

The next step is to assume a certain cross-section of the sluice, and its position. To do this, in the first instance, there seems to be no guide, properly speaking, except engineering instinct. The only

rules for the cross-section of sluices used in the drainage of salt marshes, which the writer has been able to discover in engineering literature—to be found, for example, in Hagen's Wasserbau, Part III, Vol. I, 1862; or, Treuding Ent-and Bewässerung der Ländereien, 1866; or in Buchholtz' Praktische Anweisung zum Bau hölzerner Abwässerungsschleusen, 1829—usually give the number of acres one square foot of sluice will drain, but generally do not pretend to fix definitely the position they pre-suppose for the sluice, or take into account any fresh water coming down a river, which water also must empty through the tide gates; sometimes, too, they give breadth without saying anything of height. In short, they are of little or no value to any one, unless it be to the inhabitants of the respective districts spoken of in those rules, and a consideration of the many and complex circumstances affecting the drainage of marshes will show, it is believed, that it is improper, perhaps forever impossible, to lay down rules for finding the size and position of tidal drainage sluices.

In our case this size was at first assumed to be 8 feet vertical by 10 feet horizontal, with the bottom on grade 4. (See Fig. 2, cross-section 1.) The simplest formula for the discharge of such a sluice would be $Q = A\,c\sqrt{2\,g\,h}$, in which

Q is the quantity discharged in cubic feet per second.

A is the sectional area of the submerged orifice in square feet.

h is the head on the orifice in feet.

c is a co-efficient which, according to page 31 of Samuel Downing's Practical Hydraulics, 2d edition, is probably about 0·98.

g is the velocity acquired by a body at the end of the first second of its fall in a vacuum which, in our case, for the level of the sea and latitude 42° 30′, would be, in feet, 32·1616, according to the table given in Francis' Lowell Hydraulic Experiments.

The above formula is incorrect for small heads—in our case probably by some 5 or 6 per cent.—but was adopted on account of its simplicity. To render it more approximate, however, and give the results on the safe side, the effective section of the sluice was assumed to be only 8 feet by 9 feet, instead of 8 feet by 10 feet, the co-efficient c at the same time being taken = 1.

To resume then our calculation, we shall find that from $9^{h.}$ to $9^{h.}\ 30^{m.}$ A. M., there will be discharged through the short rectangular pipe (the sluice) of 8 by 9 feet, under a head of 0·34 feet, in 1800 seconds (half an hour), a quantity of water which, taken from

the surface of 2 million square feet (the area of the river), would lower the same $\frac{72\sqrt{64\cdot3232 \times 0\cdot34} \times 1800}{\text{two millions}} = 0\cdot303$ feet. During the same time, however, we have had the constant rise of 0·176 feet per half hour to contend with; the actual fall has therefore been only $0\cdot303 - 0\cdot176 = 0\cdot127$ feet, or, since we started at 9 o'clock with the water on the inside on grade 5·40, it will be at $9^{h.}\ 30^{m.}$ on grade 5·27. This can be shown graphically by drawing the line H I between $9^{h.}$ and $9^{h.}\ 30^{m.}$ At this time the tide descends from 5·06 to 4·40, according to the adopted tide curve. We start, therefore, at $9^{h.}\ 30^{m.}$ with a head of $5\cdot27 - 4\cdot40 = 0\cdot87$ feet. Making now the same kind of calculations as previously, we shall find that at 10 o'clock the water stands on the inside on grade 4·96, and so on.*

Table I gives the data and results of all these differential calculations from the time that the tide-gates shut at 5 o'clock A. M. to keep back the fresh water then standing on grade 4, until their next closing at 3 o'clock P. M. with the water then standing on the inside on grade 1·77, all of which is also shown on the accompanying diagrams. The headings of the different columns will sufficiently explain their meaning: column 4 giving the mean velocity of efflux at the different times is interesting, and may also be of utility in designing such works—this latter more especially as regards its determination of the maximum velocity to be expected.

The final result of the examination has therefore been that, under the most disadvantageous circumstances the water will drain down $4\cdot0 - 1\cdot77 = 2\cdot23$ feet on the inside between two closings of the tide gates. Had the gates shut at the close of the investigation with the water on the inside standing where we started, on grade 4·0, it would have shown, that for the duty adopted as devolving upon the sluice, it was just large enough; as it is, we conclude that it is larger than necessary, and try again with another section of sluice, in another position. It is proper to notice here that in the above calculation there is an error, arising from the fact that inasmuch as the top of the sluice is on grade + 4., the water does not fill the same after about $11^{h.}\ 10^{m.}$ A. M., as will be seen from the diagram. The efflux becomes then of a somewhat complicated nature. It is

* Had we taken into account the variations in the amount of surface inside the river banks previously alluded to, it would have entered into each partial calculation in changing the value of the *rise* for that half hour, which would have been 0·176 near the top, and more than this when the water level is on the lower grades.

TABLE I.—*Dotted line Curve on the Diagram.*

Time of the beginning of the several intervals or differentials of time.		Time of the Ending of the several intervals or differentials of time.		Height of the water on the Outside during this interval from the adopted tide curves.	Height of the water on the Inside at the *beginning* of this interval from the curve or using the formula: $Q = A\sqrt{2gh}$.	Difference of level between the water on the inside and outside acting during this interval.	Mean velocity of efflux during this interval.	REMARKS.
A. M. or P. M.	Hours and Minutes.	A. M. or P. M.	Hours and Minutes.	On grade.	On grade.	In feet.	In feet per second.	
A. M.	5·	A. M.	5·	4·	4·	0·	0·	The tide gates shut at this time.
"	5·	"	5·30	4·40	4·	Gates are shut.	Gates are shut.	
"	5·30	"	6·	5·05	4·18			
"	6·	"	6·30	5·55	4·35			
"	6·30	"	7·	5 96	4·53			
"	7·	"	7·30	6·22	4·70			
"	7·30	"	8·	6·23	4·88			High tide.
"	8·	"	8·30	6·04	5·06			
"	8·30	"	9·	5 60	5·23			
"	9·	"	9·30	5 06	5·40	0·34	4·677	Inside high water; the tide gates open at the *beginning* of this interval.
"	9·30	"	10.	4·40	5·27	0·87	7·481	
"	10·	"	10·30	3·75	4·96	1·21	8 822	
"	10·30	"	11·	3·17	4·56	1·39	9·456	
"	11·	"	11·30	2·62	4·12	1·50	9 823	Max. velocity of efflux.
"	11·30	M.	12·	2·20	3·66	1·46	9·691	
M.	12·	P. M.	12·30	1·92	3·21	1·29	9·109	
P. M.	12·30	"	1·	1·80	2·80	1 00	8 020	
"	1·	"	1·30	1·68	2·46	0·78	7·083	
"	1·30	"	2·	1·60	2·18	0 58	6·108	
"	2·	"	2·30	1·54	1·96	0·42	5·198	Low tide.
"	2·30	"	3·	1·64	1·80	0·16	3·208	
"	3·	"	3·30	1·87	1·77	......	......	Inside low water; the tide gates close at the beginning of this interval.

probably nearer "the efflux over a weir prolonged on the down stream side, by an open rectangular canal of the same width as the weir," than any other given case of efflux that has been experimented on, so far as they are within the knowledge of the writer. Such experiments are given in Lesbros' Expérience Hydraulique, and on p. 488, Table 42, column headed Fig. 15, are the co-efficients which would probably apply to the case under investigation.* There are reasons for and against the probability of their application to the case in hand. Lesbros' experiments were conducted on a small scale, the length of his weir being only about 8 inches; this would probably make his co-efficients smaller than they should be for our case. Hence, in using them, we remain on the safe side. Then, again, the end of the exterior rectangular canal in his experiments discharged freely into the air, whereas in our case it will discharge into a bay, which again empties into the ocean, about $\frac{1}{4}$th of a mile from the site of the proposed sluice. As, however, the velocity of the water at low stages of the tide is always very great—some 5 or 6 feet per second—in the lower reaches of the river, and because the level of the water in this bay depends mainly on the state of the tide in the ocean, the two cases may perhaps be considered parallel.

(To be continued.)

ON THE DRAUGHT, HEIGHT AND AREA OF SMOKE PIPES, ETC.

By John Lowe, First Asst. Eng., U. S. N.

While attached to the Asiatic Squadron, this subject was presented to the writer's mind in a practical way. One of our vessels had a poor draught, and these investigations were undertaken to find how much addition to the smoke-pipe would produce a given result. As there is much that is new, perhaps they may not be uninteresting to the readers of the *Journal*.

If air is forced through an orifice, with a pressure equal to the weight ($w\,h$) of a column of air (h) feet high; it will issue therefrom with the same velocity (v) that a heavy body acquires in falling from the same distance (h) feet.

* They are also given, in part, in the latest American translation of Weisbach's *Mechanics*, p. 850, column A.

That is $$V^2 = 2\,g\,h, \qquad \text{(Equation 1.)}$$
$g = 32{\cdot}2$ the force of gravity.

To consume per second the required amount of fuel, we require (V) cubic feet of air per second, which passes through the area (a) of air interstices in the grate bars with the velocity:

$$V = \frac{V}{a\,c}, \qquad \text{(Equation 2,)}$$

c being a coefficient allowing for the difficulty the air experiences in passing through the bed of coal, etc.

This volume (V) of air passing through the fire is heated from the temperature t to t', and following Gay Lussac's law expands in volume from V to V′. That is $V' = V + V\,(t' - t)\,{\cdot}00205$.

The specific gravity then of the gas (as we will call the heated air) is $\frac{V}{V'}, = \frac{V}{V + V\,(t' - t)\,{\cdot}00205}$

$$= \frac{1}{1 + 1\,(t' - t)\,{\cdot}00205}, \qquad \text{(Equation 3.)}$$

Hence if the weight of 1 cubic foot of air is W, the weight of 1 cubic foot of gas is $\frac{W}{1 + 1\,(t' - t)\,{\cdot}00205}$; the preponderance P of the air over the gas is per cubic foot $P = W - \frac{W}{1 + (t' - t)\,{\cdot}00205}$ and the height H of the stack is the number of the preponderances whose total must become— $P = W\,h$.

Hence $H = \frac{W\,h}{P}$, or substituting in the last equation

$$H = \frac{W\,h}{W - \dfrac{W}{1 + (t' - t)\,{\cdot}00205}}$$

$$H = \frac{h}{1 - \dfrac{h}{1 + (t' - t)\,{\cdot}00205}} \qquad \text{(Equation 4.)}$$

By experiment $(t' - t)$ that is the difference between the temperature in the stack, and that in the ash pan was found to average 146° Fahr. Hence equation 4 becomes $H = \frac{h}{0{\cdot}2304}$.

We might reduce the entire subject to one complex formula, but for simplicity will have three, namely:

$v^2 = 2\,g\,h.$ $\quad v = \frac{V}{a\,c}$, by experiment is ·005571. $\quad H = \frac{h}{0{\cdot}2304}$

For the consumption of one pound of anthracite 195·45 cubic feet of air is taken to be required.

To conclude. The steps to be taken are: Determine the fuel required to be burnt *in toto* per second, next determine the area of air interstice in the grate bars.

From these we find first V and then $v = \frac{V}{a\ c}$. $v = \frac{V}{a \times \cdot 005571}$.

Next by substitution find $h = \frac{1}{2g} \times \left(\frac{V}{\cdot 005571 \times a}\right)^2$.

Whence $$H = \frac{h}{0 \cdot 2304}.$$

Lastly, the area of the stack is $A = \frac{a\ V}{112993}$, arising from the same considerations that produce equation 3.

THE PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Joseph M. Wilson, C. E.

[P. A. Engineer, Construction Department, Pennsylvania Railroad.]

(Continued from page 41.)

Store House.—Plate I gives the location of the store house, it being marked 5. It is intended for the reception of all articles which it is necessary to keep in stock for use in the shops. Plate X shows the plan of the first floor, a cross section, and a portion of the side elevation of the building.

It will be noticed that the back portion of the house is used for the storage of wrought iron in bars and sheet iron, and has no cellar. The large doors to this apartment are hung on weights, and open by sliding upwards. The front on the first floor is the store room proper, and contains an office for the storekeeper, and a counter, the sides and centre of the room being conveniently fitted up with the necessary shelving, drawers, nail boxes, &c.

Underneath this portion is a good cellar, having outside and inside entrances, and is used for storage of heavy articles.

There is a second floor extending over the whole building, communicating by a stairway with the first floor, and having also a hatchway for lifting goods, in the floor directly over the first-story entrance.

The building is of brick, with substantial stone foundations, and covers an area of 3085 square feet, the details of construction being on the Plate. The floors are supported through the centre of the building by a row of cast iron columns, with wrought iron I beams extending from the columns to the side walls. The cellar columns are 8 inches at the smallest outside diameter, and of $\frac{3}{4}$-inch metal. The first-floor columns are 6 inches at the smallest diameter, and also of $\frac{3}{4}$-inch metal. The I beams are arranged in pairs, two beams at each position. They are 9 inches deep, weighing 70 pounds per yard, and are connected on top by a plate of boiler iron $\frac{3}{4}$-inch by 8 inches section. The floor joist are 3 by 12 inches section, placed one foot apart, centre to centre; the flooring on the first story being 2-inch yellow Carolina pine, and on the second story 2-inch white pine

The second floor is not lighted by windows, but by a skylight, extending along the ridge of the roof, and shown on the Plate, formed of $\frac{3}{8}$-inch rolled glass. Along the sides of the skylight ventilation is secured by long narrow valves, which may be opened and shut at pleasure by cords attached.

The roof has a one-quarter pitch, and is hipped at the ends. The principals are placed fifteen feet apart, centre to centre, the form of truss and sizes of parts being given on the Plate. The covering is of slate, laid upon close sheeting boards and tarred felt, with galvanized nails, and the cornice to the building is of galvanized iron. The main store room is warmed by steam coils from a boiler used in heating the oil house adjoining.

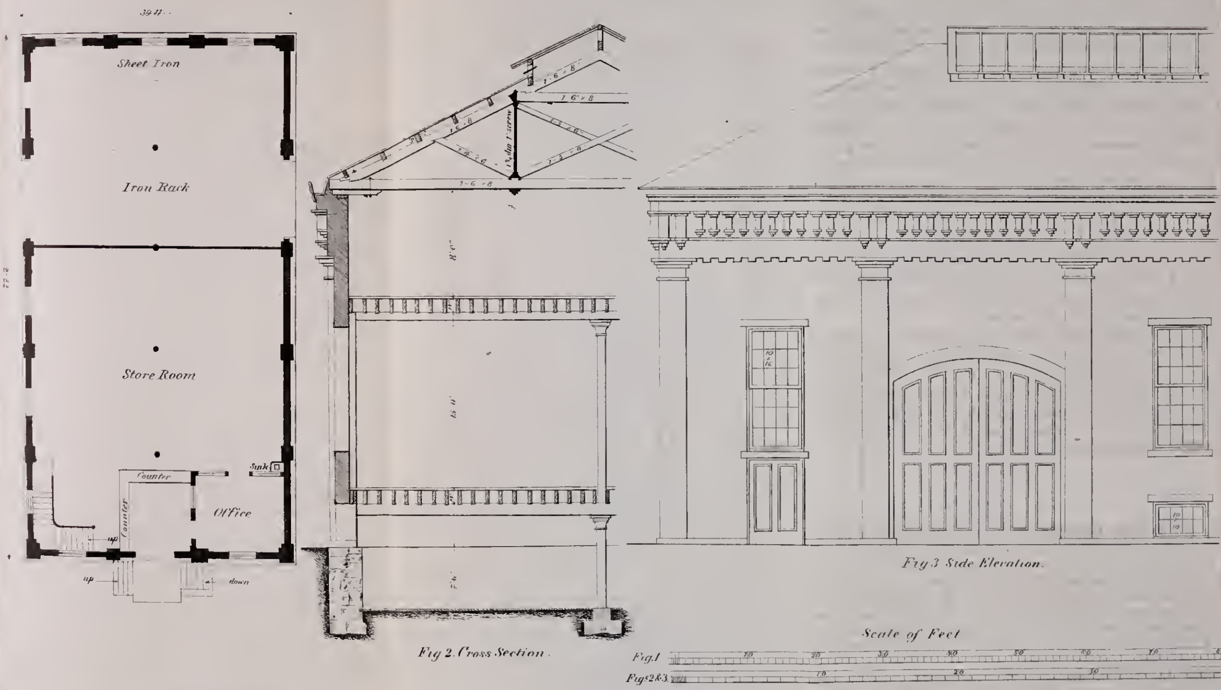
(To be continued.)

The North Pole Expedition.—By the time this notice appears the exploring expedition under the command of Capt. C. F. Hall will have departed upon its perilous voyage. The scientific department is under the direction of Dr. Emil Bessels, and is furnished with detailed series of suggestions as to its operations from the National Academy of Sciences. It is to be hoped that the expedition may be successful enough to warrant an extension, or at least a continuance of the liberal policy of the government in the cause of scientific inquiry.

Spectrum of Uranus.—Dr. Wm. Huggins has given to the Royal Society an account, illustrated by an engraving, of some spectroscopic observations upon the planet Uranus, from which it appears that its spectrum differs in a remarkable degree from that of the other planets.

Pennsylvania Railroad Shops, West Philadelphia.

Store House.



Construction Dep^t Penn^a R.R.

Mechanics, Physics, and Chemistry.

ON THE CHANGE OF COLOR PRODUCED IN CERTAIN CHEMICAL COMPOUNDS BY HEAT.

By Prof. Edwin J. Houston.

Of the Central High-School of Philadelphia.

At a meeting of the Optical Section of the Franklin Institute, held April 26th, 1871, Dr. Wm. H. Wahl exhibited specimens of the double iodides of mercury with copper and silver, discovered by Meusel.* The color of each of these salts is changed in a remarkable manner by the action of obscure heat rays. The author, in connection with Mr. Elihu Thomson, of the Central High School, was led to undertake an extended series of experiments, with a view of ascertaining the law by which these peculiar changes are governed. The author desires to state that Mr. Thomson's share of the investigations was equal to his own.

Familiar changes of a similar though less striking nature, at once suggested themselves, among the most prominent of which, might be mentioned the darkening of the red protoxide of mercury in the preparation of oxygen.

The experiments were conducted as follows: the substances were placed in the state of dry powders on strips of sheet copper, and heated by means of an ordinary Bunsen burner.

It soon became evident that quite a number of compounds underwent a change of color when so exposed. The colors observed, however, together with those already known, appeared at first to present facts of the most discordant nature.

In some cases the colors were changed so as to approach the violet end of the spectrum, while in others they approached the red end. To avoid all sources of error, the conditions of the original experiment were carefully considered. Briefly they are as follows:—

1. A certain color presented by the compound at ordinary temperatures.

2. A decided change of color, on the application of obscure heat rays.

* Ber. d. deutsch. Chem. Gesell. III. 123. Jr. für Prak. Chem. ii. II. 136.

3. A complete return of the original color on the removal of the heat, and the cooling of the body to its former temperature.

Bodies not presenting all these phenomena were rejected.

The largest class of bodies that was excluded by this method, was that in which a permanent change of color was produced by heat. In this case the change is caused either by the heat being raised to a temperature sufficient to cause a decomposition of the body, by a change from the amorphous to the crystalline state, by a partial sublimation and subsequent deposition of the sublimate, by a change in the crystalline form, or by some other permanent change in the arrangement of the molecules.

Changes in color produced by dehydration were also rejected, as for instance, in the case of the chloride of cobalt, which, when hydrated, is a pale pink, but when anhydrous, a deep blue. Hydrous and anhydrous salts are distinct chemical compounds, and have therefore a different molecular arrangement. A class of cases of a somewhat similar nature was also rejected. Here the change of color was produced by a loss of the water of crystallization, as for instance, the sulphate of copper, which changes from a deep blue to a white.

After these sources of error were removed and quite a number of bodies discovered presenting phenomena fulfilling all the requirements of the original experiment, the law became evident. *In every case the color in its change approached the red or heat end of the spectrum.* Not a single exception to this law was observed.

Before stating the explanation of the way in which these changes are produced, a few words in reference to the relation existing between light and heat may be necessary. That light and heat are produced by a vibratory motion of the molecules of bodies, and that they differ from each other, merely in the rapidity of the vibrations of these molecules, the facts presented by the science of the present day, leaves scarcely room for doubt. A hot body differs from another cooler than itself, not in virtue of any peculiar substance or fluid, which it possesses, but simply in the fact that its molecules are in more rapid motion. Increasing the temperature of a body is equivalent to increasing the rapidity of the vibration of its molecules. As the body is made hotter, its molecules vibrate more and more rapidly, until finally a *red heat* is obtained, and light is emitted along with the heat. Now we know that a ray of white light, popularly speaking, is a mixture of seven different kinds of

rays, viz., the colors of the solar spectrum. Moreover, we know by actual measurement, that these colors, in the order of the number of vibrations required to produce them, commencing with the least, are as follows: red, orange, yellow, green, blue, indigo and violet, those of the violet being about twice as rapid as those of the red.

If then light differs from heat, merely in the fact that the molecules of a body emitting light, are in more rapid motion than those of a body emitting heat, when that rapidity in the vibrations of the molecules of a hot body is reached, that it commences to give out light along with the heat, the color first emitted should be red, since that color is produced by the least number of vibrations per second, and the colors which successively appear should be orange, yellow, green, blue, indigo and violet, until finally, these by their intermixture produce white light, and the body becomes *white hot*. These considerations are fully sustained by the beautiful experiment of Draper, who viewed through a prism, the light emitted by a platinum wire, heated by a current of dynamical electricity. The color which first appeared was red, and then successively, orange, yellow, green, blue, indigo and violet, or more accurately when the platinum wire became white hot, it gave a continuous spectrum from the red to the violet.

The boundary between heat and light then, is found at the extreme end of the red of the spectrum. It is evident that though the range of the spectrum must vary with the sensibility of the eye of the observer, that is that the heat vibrations will become light vibrations sooner to some eyes than to others, yet in all cases the color first observed will not be a pure red, but a dark brown; a color produced by the mixture of black, or the absence of color, with the few red rays first emitted.

It should be borne in mind that the arrangement of the spectrum into seven colors is merely a matter of convenience. In point of fact there is an almost infinite variety of tints. The red, for instance, is merely taken at the mean of the dark red and the orange-reds, and so for the other colors.

Remembering these preliminary considerations a fuller statement of the law of the changes may now be given.

In all cases in which the color of a body is changed by the application of heat, and the original color regained on cooling, the nature of the body being in no wise altered, the character of the change is as follows: the addition of heat causes the color to pass from one of a

greater to one of a less number of vibrations; the abstraction of heat from one of less to one of a greater number.

In accordance with this law, violets are changed by heat into indigo-violets or indigoes, indigoes into blues, blues into bluish-greens or greens, greens into yellowish-greens or yellows, yellows into orange-yellows or oranges, oranges into orange-reds or reds, and finally reds into brownish-reds or blacks; by cold the inverse order is observed. In many instances substances were noticed that ran down the scale two or more colors; for example, the green iodide of mercury, which passes from yellowish-green through the yellow, and orange to the red.

Among the most sensitive substances noticed, are the following, arranged by their colors in the order of the spectrum.

Reds.—*Ferro-Cyanide of Copper.*—Color at ordinary temperature, mahogany-brown; darkens by heat to brownish-black, original color returning slowly on cooling.

Brown-Red Sulphide of Antimony.—Kermes Mineral.—Color brownish-red; changes to darker brownish-red.

Anhydrous Sesqui-Oxide of Iron.—Color, brownish-red; changes to dark red, brown, brownish-black and black at a temperature greatly below a red heat.

Sub-Iodide of Copper.—Color, dark red. The changes presented by this substance are very remarkable. On the application of quite a low heat it changes to darker-red, and afterwards to a brownish-red, brown, brownish-black and finally almost a black. The return to its original color on cooling is rapid.

Proto-Sulphide of Mercury.— Vermilion.—Color, bright red, or vermilion; darkens to brownish-red.

Sub-Chromate of Lead.—Color, red; changes quite readily to dark red and brownish-red.

Red Oxide of Lead.—Red Lead.—Color, red; changes readily to dark red.

Bi-Chromate of Potassa.—Color, red; changes to dark red. The change in this case is best observed by heating a small crystal of the salt.

Oranges.—*Bi-Sulphide of Arsenic.—Realgar.*—Color, when pulverized, orange-red; changes to red, dark-red and brown; returns readily.

Protoxide of Mercury.—Red Precipitate.—Color, orange-red; changes to red, dark red and brownish-red.

Iodide of Lead.—Color, orange; changes to darker orange, orange-red and red.

Oxalate of the Protoxide of Iron.—Color, light orange; darkens. In this case the heat must be quite low, as the substance is readily decomposed.

YELLOWS.—*Chromate of Lead.*—Color, yellowish-orange; changes to orange, orange-red and deep orange-red.

Sub-Sulphate of Mercury.—*Turpith Mineral.*—Color, yellow; changes to orange-yellow, orange and orange-red.

Chromate of Baryta.—Color, yellow; changes to orange-yellow.

Bi-Sulphide of Tin.—*Mosaic Gold.*—Color, brownish orange-yellow; changes to a dark red very nearly approaching a black; quite sensitive.

Ter-Sulphide of Arsenic.—*Yellow Orpiment.*—Color, orange-yellow; changes to deep orange-yellow, yellow, orange-red and red.

GREENS.—*Sub-Iodide of Silver.*—Color, greenish-yellow; very sensitive; changes first to an orange-yellow, and then to a deep orange.

Sub-Iodide of Mercury.—*Green Iodide.*—Color, yellowish-green; more sensitive than the preceding; changes to a yellowish-green, and then successively, to an orange-green, reddish-orange, red, and brownish-red. These changes succeed each other very rapidly. They may be best observed by heating at once up to the brownish-red, and noting the changes of color that occur as the body cools.

In all the above cases the original color is fully regained on cooling.

The substances named are by no means all that have been observed to come under the law. Quite a number of other compounds have been noticed; but none of them are as sensitive as those already mentioned. In no case, however, has any compound been found of the color of blue, indigo, or violet, that, in the solid state, undergoes any decided change whatever, on the application of a temperature short of that producing, either a decomposition, or a permanent change in the arrangement of its molecules. Nor is this fact contrary to what might be expected. Near the heat end of the spectrum, where the difference between the light and heat vibrations is not so great, we might reasonably expect the particles of a solid to be influenced by each, and to accept a motion which should be a mean of the two, but when we get as far in the spectrum as the blue or indigo, the greatest heat that we can intermingle with the

blue or indigo, even if pushed to the point of incandescence, would be but dull red. Now long before this temperature is reached, most bodies would undergo decomposition, and were this not the case, even then, we could hardly expect the particles of a solid, trammelled as they are in their freedom of motion by the force of cohesion, to accept a mean of two kinds of vibrations, which differ so greatly in their wave lengths. Still it must be borne in mind that solids differ very greatly from each other in the freedom of motion of their molecules, and it is not improbable that a number of solids as high in the scale of color as the blues, indigoes or violets, may eventually be found conforming to the law.

A few very significant facts were noticed in this connection in the case of two pure white substances, viz., the oxides of zinc and of tin; their behavior is as follows:

Oxide of Zinc. Nihil Album; color, white; changes on the application of heat to a scarcely perceptible bluish-white, green and yellowish-green. Does not entirely return on cooling though it resumes nearly its original color.

Oxide of Tin; color, white; here the range is more remarkable. It changes first to a pale-green, then to a decided yellowish-green, and even runs as far down the scale as orange and reddish-orange: returns on cooling to a greenish-white.

These two substances have not been included in the regular list of solids, as they fall somewhat short of the conditions of the original experiment. They conform sufficiently to it, however, to call attention to their behavior.

Experiments were also made on solutions of various solids. As a general rule, it has been found that a substance in solution is more sensitive to the action of heat, than when in the solid state. This, indeed, should be so, as the action of the solvent is simply, by its adhesion for the solid, to separate it into very small particles and to give them much greater freedom of motion. Solids in solution have been found, as high in the scale as the violet, which conform perfectly to the law.

These experiments were conducted as follows; the solution was made of the required strength and then divided between two thin glass test-tubes, of the same size and thickness. They were then held, side by side, between the eye and the light, and carefully compared by transmitted light. If any difference in tint was observed, the solutions were poured together and again thoroughly mixed.

If any difference still existed on again dividing them between the two test tubes, one of the tubes was rejected as differing in thickness or color from the other, and replaced by another until exactly the same tint was obtained. It will readily be seen that these precautions were necessary, in order that the results obtained should not be equivocal. One of the solutions was heated in a Bunsen burner, and the change carefully noted by comparison from time to time. Of course the highest temperature was limited to the boiling point of the solution under the pressure of the atmosphere. In many cases, however, decided changes were observed long before even this point was reached. No experiments were tried on temperatures obtained by boiling under high pressures in confined glass vessels, though there is every reason to believe that by these means splendid results would be obtained. It is purposed, if time allows, to pursue the investigation in this direction, at some future day.

Of course, in all cases where the color did not entirely re-appear on cooling, the experiment was rejected.

The solvent used was water. As the color of a solid in solution varies with the strength of the solution, it will be understood that in all cases the amount of solid dissolved was that requisite to produce the tint described.

The following are among the most sensitive substances noticed.

REDS.—*Rose Aniline;* solution of a strength sufficient to produce a decided red; darkens perceptibly on the application of a boiling heat.

Decoction of Logwood; solution of a deep red; darkens on the application of heat.

Chloride of Cobalt; color of solution, pinkish red; changes to a darker pinkish red.

Sesqui-Sulphate of Iron; color of solution, light-red; changes to brownish-red.

ORANGES.—*Chromic Acid;* color of solution, reddish-orange; changes to an orange mixed with a greater amount of red.

Bichromate of Ammonia; color of solution, orange-red; changes to a pure red.

Sesqui-Chloride of Iron; color of a weak solution, orange-red; very sensitive; changes to red and brownish-red.

Bi-Chromate of Potassa; solution of an orange-red; changes to a red.

YELLOWS.—*Sesqui-Nitrate of Iron;* color of solution, brownish yellow; changes to brownish red.

GREENS.—*Ferro-Cyanide of Potassium;* solution of a yellowish green; changes to a yellow.

Chromate of Potassa; solution of a yellowish-green; changes to a yellow.

Nitrate of Nickel; solution, pale-green; changes to pale yellowish-green.

Sulphate of Nickel; solution, green; changes to yellowish-green.

BLUES.—*Chloride of Copper;* color of weak solution, bluish-green; changes to a very decided yellowish-green. This substance is quite sensitive, the color returning rapidly on cooling.

Sulphate of Copper; solution of a decided blue; changes to a very decided green at the boiling point of the solution. Returns to its original color rapidly on removal from the heat.

VIOLETS.—*Ammonio-Oxide of Nickel;* solution of a violet-blue; changes to a light blue; returns fully on cooling, and cannot therefore be attributed to any loss of ammonia.

Solution of Litmus; color, violet; changes to an indigo-blue.

It may be objected that the substances noticed do not present as great a range of changes as those observed in solids. It must be remembered, however, that the temperature in no case differed much from the ordinary temperature, being never much greater than 220° F., while in the experiments with solids the temperature was often more than three times as great. We feel sure that experiments with liquids at higher boiling points, will show substances running down the scale much further than the observed solids.

The Action of Cold.—It would appear from the law already stated, that the color of a body is affected by its temperature, and that in proportion as this temperature is raised, the color is lowered; moreover, considering the color emitted by the body at its higher temperature, the color is always raised in the spectrum as the body cools. For example, take the case of the green iodide of mercury, which, as before mentioned, is yellowish-green at ordinary temperatures. By the action of heat, its color is successively lowered through the yellow, orange and red, which latter is reached at the maximum temperature of exposure. Cool the body from this point, and its color will become orange, yellow, and yellowish-green, respectively.

Now, the same reasoning that applies to the cooling of the body

from this higher temperature, should also apply, though not with equal force, to its cooling from any temperature, such, for instance, as that of the place in which the body is situated. The color emitted by a body at any temperature, is always lower than it would be were it not for the intermingling of the heat vibrations. Remove it as much as possible from the influence of these vibrations, or in other words, cool it, and the emitted light must be of a higher pitch or color. It would appear then, that as the effect of raising the temperature of a body above its ordinary temperature is, to lower the pitch of the emitted light, so cooling it below that temperature, must be to raise the pitch. The raising, however, would hardly be as great, proportionally, as the lowering. As we recede from the boundary of the heat and light vibrations, we lessen the chance of their producing by intermingling a resulting mean vibration.

With a view of testing the truth of these theoretical considerations, experiments on the action of cold on substances in both the solid and liquid condition were made.

Solids.—The reduction of temperature was obtained by the evaporation of Ether, Bi-Sulphide of Carbon, or liquid Sulphurous Acid. The liquid was placed in a metallic box, furnished with eight vertical sides. Strips of paper, on which the substances were painted, were pasted on the sides of the vessel. Corresponding strips of paper, similarly prepared, were kept for comparison. Cold was produced by blowing a blast of air from a small bellows upon the surface of the liquid. The results obtained were somewhat vitiated by the deposition of the moisture of the air on the sides of the metallic vessel. This difficulty was obviated to some extent by having the paper slip, kept for comparison, equally moist. The results, which are open to this objection, were as follows:

Sulphide of Mercury; changes from a bright red to a brighter red.

Bi-Sulphide of Tin; changes from a brownish orange-yellow to a lighter brownish-yellow.

Sub-Sulphate of Mercury; changes from a yellow to a greenish-yellow.

Iodide of Lead; changes from an orange to a lighter orange.

Chromate of Lead; changes from a yellowish-orange to a yellowish-green.

The substances occupying the remaining sides of the vessel did not present any appreciable change.

Liquids.—The experiments with liquids were, with a few exceptions, of an unsatisfactory character. The solvent in most cases was water, and the cold could not safely be pushed lower than the point of maximum density of the solutions. The solutions were prepared in test tubes, in a manner similar to the experiments with heat. The limitation in the application of cold was, in all probability, the cause of the changes not being of a more decided character.

The following are among some of the substances experimented with:

Sulphate of Copper; solution of a pure blue; deepens on the application of cold.

Ferro-Cyanide of Potassium; saturated solution of a nearly pure yellow; becomes tinted slightly with green.

Chloride of Copper; solution of a bluish-green; becomes a more decided bluish-green.

Sesqui-Chloride of Iron; solution, orange-yellow; becomes an orange yellow in which the yellow is more predominant than in the preceding.

Sesqui-Nitrate of Iron; solution, orange-yellow, like the chloride.

Wishing to obtain a solution that could be exposed to a much lower temperature without freezing, a solution of the chloride of copper in ether was prepared. The color was yellowish-green. When exposed to a low temperature by the evaporation of the bisulphide of carbon, the color changed very decidedly to a pure green. It is purposed, at our earliest convenience, to pursue these investigations at lower temperatures obtained by means of solid carbonic acid and ether. Meanwhile, we would be much pleased if any investigators throughout the country, who may be using a solution of the solid carbonic acid in ether, would observe the action of intense cold on the etherial solution of chloride of copper, or on any solution of a similar nature.

The law already stated seems now to have been clearly established, both by the number of cases that come under it, and by the fact that, so far, no exceptions have been noticed. It can hardly be urged, with fairness, that all colored compounds should be equally influenced by the action of the less rapid heat vibrations, for the differences presented by bodies, as regards their transparency or opacity to light, or their diathermancy or adiathermancy to heat, clearly indicate a very great difference in their molecular structure, which difference offers reasons amply sufficient to explain why the

colors of some compounds should be more influenced by heat than others. Again, there can be little doubt that more extended observations will increase the great number of compounds already noticed. For, instance, the well known change from red to yellow, presented by the red iodide of mercury, dissuaded us at first from submitting it to an experiment. On a careful trial, however, it was found to illustrate the law, changing to a decidedly darker red up to the temperature requisite to alter its crystalline form.

The theory also receives further support and confirmation from the following considerations.

It is well known that when a yellow and a red substance, which have no chemical action on each other, are mixed together, the resulting color is orange. The explanation is undoubtedly to be found in the raising of the less rapid red vibrations by the yellow, and the consequent lowering of the yellow by the red, the mean, resulting vibration being that capable of producing orange light.

This case, though analagous to the change produced in color by the action of the heat, is not strictly identical with it. In an orange substance, which emits red light when heated, the change is produced as follows; its molecules, while vibrating in periods requisite to produce orange light, are, at the same time, forced to accept the less rapid vibrations of heat. They are unable to do this without lowering the rapidty of the light vibrations, and the emitted light is red. Here, however, the molecules themselves transmit red light to the ether surrounding the intermolecular spaces, which ether in its turn transmits it to the eye for the purposes of vision. Now, in the case of the orange light emitted after the commingling of a yellow and a red substance, as no change other than that of mixture is produced, we must still conceive of the particles of the red and of the yellow substance vibrating in periods requisite to produce red and yellow, and the interference taking place in the intermolecular spaces. Briefly the difference is as follows: In the substance whose color is changed by heat, the *molecules* transmit the changed light directly to the surrounding ether, while in the commingled bodies, the change occurs in the ether surrounding the molecules. The two cases become strictly analagous when we mingle red and yellow light.

In accordance with this view, pure orange and green when mingled should produce yellow; yellow and blue, green; green and indigo, blue; and blue and violet, indigo.

When we come to the boundary of the spectrum on the light side, in other words when we come to the violet, an apparent objection meets us. We know that violet can be produced by the mingling of indigo or blue light with red. That is *two lower vibrations*, and one of them at the lowest extremity of the visible spectrum, produce by their mingling a resultant *higher vibration*, a fact certainly improbable, and seemingly at variance with theory. It must, however, not be forgotten that the violet of the spectrum marks not the limit of the etherial vibrations, but merely our power of appreciating them. The existence of higher vibrations is shown by the actinism of the spectrum, or the effect in producing chemical decomposition, existing some considerable distance beyond the violet. In fact, Herschel, by concentrating this invisible light beyond the violet, succeeded in rendering it visible, and gave its color the name of lavender. This light is of a pale red, inclining to a tinge of violet.

The explanation is now simple. The violet of the spectrum is not produced by the mingling of the indigo or blue with the remoter or lower red, but with that of the higher red or lavender. Indeed, we are strongly led to the belief in the existence of a spectrum beyond the visible spectrum, whose colors, could the eye be trained to appreciate them, would be lighter tints of the lower color. This spectrum would then begin with a paler, shriller, higher red, which we actually have in the lavender. The next, which will probably some day be rendered visible, would be a paler, shriller, higher orange; and so on through the yellow, green, and the other colors.

The analogy of the less rapid vibrations requisite to produce sound is in strict accordance with these considerations. Take, for instance, the note C of the natural gamut; it requires for its production, say 128 vibrations per second; if we increase the rapidity of the vibrations to 144, we get the next higher note, or D; at 160 vibrations, E; at $170\frac{2}{3}$, F; at 192, G; at $213\frac{1}{3}$, A; at 240, B; and at 256, or just twice the number of vibrations requisite to produce C, we get a higher note, which we call C′, which, though it differs from C in its pitch, and probably in its timbre, still bears to it in many respects a striking resemblance.

The visible range of colored notes also constitute one octave, viz: red, corresponding, say, to C; and then orange, yellow, green, blue, indigo and violet, corresponding respectively to D, E, F, G, A and B. The octave, or the lavender, corresponding to C′, can only be appreciated by the eye under favorable circumstances.

It is most probably more than a mere coincidence that the interval between the lower and the higher red, which is $\frac{1}{2}$, is exactly the same as the interval between the higher and the lower c. Indeed, calculations we have made, show a remarkable similarity in the intervals between the different colors of the spectrum, and the notes of the natural gamut with which we have compared them.

The same reasoning applies to the colors of the spectrum beyond the red, on the heat side, the next color to which, could it be appreciated by the eye, would probably be a very dark reddish-violet, or a purple. In confirmation of this view, we have noticed that some reds, in turning into browns and blacks, possess a slight tinge of purple.

THE SUN.

A Course of Five Lectures, before the Peabody Institute of Baltimore.

By Dr. B. A. Gould.

(Continued from page 66.)

In 1852, nine years after Schwabe's discovery of a period in the spottiness upon the sun, Prof. Wolf, of Berne, was led, by careful study of the observations in connection with ancient records, to a modification* of the length of the period, which Schwabe had roughly fixed at about ten years. The large spot which Keppler saw before the discovery of telescopes and took for the planet Mercury, in 1607, indicates that the time of maximum could not then have been far off, and since Fabricius saw the sun at times without spots, his observations must have been during a period of minimum spottiness. Critically examining the various observations of Galileo, Scheiner and others in the early days, and thus following the records of different observers for about two and a half centuries, he found† that the total series was best represented by a period of $11\frac{1}{9}$ years. Only a year earlier than these researches of Wolf, Lamont in Munich had found out the remarkable fact‡ that the variations of the earth's magnetism are subject to a periodic recurrence

* *Astron. Nachrichten*, XXXV, 369.

† *Neue Untersuchungen über die Periode der Sonnenflecken, etc. Mittheilungen d. Berner naturf. Gesellschaft.* 1852.

‡ *Ueber die 10-jährige Periode, welche sich in der Grösse der täglichen Bewegung der Magnetnadel darstellt.*—Pogg. Annalen, LXXXIV, 572.

once in about $10\frac{1}{3}$ years, and Wolf succeeded in proving that the very period of $11\frac{1}{9}$ years, which he had found to be the most probable one for the sun-spots, answered also for the variations of terrestrial magnetism better than that found by Lamont himself.* Thus it became evident that the interval at which the phenomena periodically repeat themselves is the same for solar spots and for variations in the direction of the magnetic needle; or, at least, that any difference in the length of the two periods is too small to be yet detected—and it is but natural that this so remarkable coincidence should suggest an identity of cause. Whether this is really so or not, we have no other evidence to decide. Almost simultaneously with Wolf's announcement, two other investigators, Gautier † in Geneva, and Sabine ‡ in London, independently called attention to the similarity of the periods for the two phenomena, both in their duration and in the epochs of their greatest and least intensity. It must now be accepted as a fact that the maximum number of sun-spots occurs in the same years with the greatest variation of the declination of the magnetic needle, and *vice versa;* so that the observation of one of these phenomena serves to indicate the facts concerning the other.

Nor is this all that has been learned concerning the spot-period; for besides this period of the ninth of a century in their frequency, more minute investigation showed a regular variation in this period itself, by which once in seven or eight periods the maximum frequency occurs sooner, by two or three years, than this law would indicate—the preceding interval being too small, and the following one too large by this amount. The cause of this periodic fluctuation in the period is known as little as that of the period itself, nor have the observations of terrestrial magnetism extended over a sufficient series of years to make it manifest where any similar phenomenon is exhibited there also; other interesting and singular researches have been made, which it has been claimed establish a connection between the amount of spottiness in the sun and the positions of the planets. These inquiries, began by Wolf and Schmidt, have been continued on an extended scale at the Kew Observatory, and these investigators believe that they have found a close relation between the positions of Venus and Jupiter, and probably also the

* *Berner Mittheilungen*, 1852, p. 183, July 31.

† *Bibliotheque Universelle*, July and August, 1852.

‡ *Philosophical Magazine*, Sept., 1852 (presented to Royal Society, March, 1852.)

Earth, on the one hand, and the amount of sun-spots on the other. Indeed, it is maintained that the position of the spot-zone upon the sun's surface is itself subject to periodic changes, dependent upon the latitude of Venus. There is no time for us to enter into any discussion of this subject at present; but I think I may say that although the various arguments have been presented with great ability, and much that is plausible has been adduced in their favor, they have not yet found general acceptance with astronomers. Again, it has been maintained that auroras and magnetic storms, which appear to be only different manifestations of the same phenomenon, are more numerous in those years when solar spots are most abundant, and comparatively infrequent in other years. The same, too, has been said of earthquakes. But all these ideas can scarcely claim any higher rank than that of suspicions or surmises; certainly they are far from being proved or from finding assent among scientists as a class. The same is the case with the inferences concerning a curious occurrence which you will find described in some popular books, and which took place on the 1st of September, 1859. It was seen by two English observers, some 20 or 25 miles distant from each other, Messrs. Carrington at Red Hill and Hodgson at London. The first named gentleman saw* two very bright patches of light break out in the midst of a large group of spots, and traversing in $5^{m.}$ a space of 35,000 miles, fade rapidly away as two dots of light, before they had reached the margin of the group. The other described† a single very brilliant point of light like a star, which illuminated the upper edges of the neighboring spots and streaks, and after about $5^{m.}$ disappeared instantaneously. This curious phenomenon was without any precedent on record, and Mr. Carrington, calling at the Kew Observatory a day or two afterwards, found that at nearly the same time the self-registering magnetic instruments there had experienced a sudden disturbance. To this interesting coincidence he naturally gave publicity, although without any such unphilosophic inference as, that because the phenomena were simultaneous they must be connected in causation. Still, the temptation to make a striking inference seems to have been too strong to be resisted by sundry writers of popular treatises, and you will find in many publications in our own language such statements as that the two phenomena took place at precisely the same instant, and that their sudden disturbance in the sun sent its instantaneous

* *Monthly Notices Royal Astr. Soc.*, XX, 13. † *Ibid.*, XX, 15.

influence to the farthest recess of our system. These are statements unsupported by the record. The disturbance of the magnetic instruments appears to have taken place at $11^{h.}$ $15^{m.}$ A. M., lasting about three minutes in its vigorous action, and about $7^{m.}$ more before it abated.* The outbreak of the bright patch on the sun was not until $11^{h.}$ $18^{m.}$, and in $5^{m.}$ Greenwich time all traces of it had disappeared. The magnetic perturbation was only one of many minor fluctuations during a great magnetic disturbance and series of auroral displays, which continued from nearly four days previous until more than 5 days subsequent to the solar phenomenon. Bearing these facts in mind, it would seem that other indications of some physical connection between the two would be needed to justify the opinion that the near approach to simultaneousness was anything more than a "curious coincidence." The magnificent exhibition of the Northern Lights on the nights of August 28 and September 1, 1859, will doubtless be remembered by many of you. This 9-days series of auroral displays was among the most beautiful, and the accompanying disturbances of the magnetic needle were among the most intense of the last fifteen or twenty years. During a portion of this time the large groups of spots referred to was a conspicuous object upon the sun, and on the day named a somewhat larger amount of area was occupied by spots than on any other during Carrington's series, although the excess was not very great. The magnitude of the magnetic disturbance at the moment in question was not comparable with that on many other occasions during the series, nor would it have attracted notice during the 21 hours' agitation of the needle three days previous, or during the 3½ days of perturbation which set in 18 hours afterwards. As regards the supposed relations between the frequency of auroras and the amount of spotted surface upon the sun, I should add that Prof. Lovering, of Cambridge, has recently published a most elaborate and highly valuable memoir, in which he has made a catalogue of all auroras to be found on record, and has carefully discussed their relative frequency at different times. Although the fact that they are periodic is thoroughly demonstrated by these copious materials, yet no relation whatever is indicated between the auroral period and that of the solar spots, nor indeed does Prof. Lovering find any reason for supposing the two phenomena to be at all connected with each other.

* Stewart. *Philos. Trans.*, 1861, p. 426.

That the total heat of the sun is perceptibly less in those years when the spots are most abundant, appears to be an established fact. Schwabe thinks that those years in which they are least numerous generally afford the largest proportion of clear days, and he also mentions that although he has always used his telescopes in the same way since the commencement of his solar observations, more than forty years ago, the heat concentrated in the focus has never cracked his shade glasses except during those seasons in which spots were comparatively infrequent. And it should not be forgotten that the year in which Pouillet made his measurements of the sun's heat, viz., that beginning June 1, 1837, was almost at the time of the greatest spottiness. A repetition of these measures at different epochs of the spot period is greatly to be desired.

There remains but one point to be considered before passing from this subject of the spots, which may, I fear, have grown tedious to you. It is the question whether there are any special points or regions upon the sun where disturbances of the surface are especially prone to break out. The interest of the question at present is due rather to the zeal with which it has been investigated by many astronomers, and to the wide difference in their conclusions, than to any well grounded uncertainty which now exists upon the subject. Spots have been recorded in N. lat. as high* as 50°, and as far South† as the lat. of 45°, but these are the outer limits unless we accept an ill-substantiated statement of a spot seen at 70° N. The existence of the spot-zone has been known since the earliest observations; and that of the inner equatorial belt within which they rarely occur, and which divides the spot-zone into a northern and a southern half, has likewise been established for some forty years; but the question to which I now allude is whether there are within the spot belts, particular points at which the spots appear to originate more abundantly than elsewhere. The affirmative has been maintained by Peters after study of a very considerable series of observations made at Naples, for the purpose of determining this very question, and even Schwabe thought that some of his observations indicated the existence of one such fixed point; but Carrington's observations indicate the reverse very decidedly. Indeed, now that we know the body of the sun to be at a temperature totally inconsistent with our ideas of solidity, and have every reason to believe it only

* *Proc. Amer. Asso. Adv. Science*, 1855, p. 92.

† Carrington, *Observ. of Solar Spots*, p. 157.

a gaseous mass incapable of permanent inequalities of surface, or local features, and in fact must regard it as demonstrated that even its rotation is that of a yielding and scarcely plastic mass—since it actually moves with different angular velocities at different distances from its equator—the question appears to answer itself; certainly it loses its significance.

We see that, as I have already said, our sun is a variable star, having a period of slightly diminished brilliancy once in about 11$\frac{1}{9}$ years, and a secondary fluctuation * of this period once in about 80 years. Wolf has compared this form of variability with that of sundry variable stars known to us, and thinks † that in this respect our sun most nearly resembles the star *η Aquilæ*.

In addition to our study of the quantity and intensity of light, two modes of investigating its quality are known to us. One is by discovering in what planes the luminous undulations occur; the other is by determining the proportion of rays of each degree of refrangibility which it contains.

A single beam of ordinary white light—the smallest that can affect the eye—consists by no means of a single ray, but of a multitude of rays so numerous as to baffle any attempt to express them in figures within the range of our appreciation. All the vibrations which constitute a ray, or beam, are at right angles to its direction, or axis; but in ordinary light they take place in every possible plane which passes through this axis, being in all directions around it, so that, coarsely speaking, the shape of what is commonly called a ray of light may be considered as cylindrical—formed by the contour of a multitude of individual rays, situated in different planes, although coincident, so far as their common axis is concerned. ‡ Now, there are various influences which may change the plane of vibration for some of these component rays. One of them is obliquity of reflection, another is obliquity of emission from a solid or liquid surface, and there is a certain angle at which reflection will do it so completely as to throw all the vibrations into one single

* *Astron. Nachrichten*, LXV, 63. † *Ibid* LXIV, 133.

‡ This statement must not be too literally interpreted. What I desire to say is, that a single ray of ordinary white light is equivalent to what we must at present consider as an immeasurably large number of rays, in every possible plane around their common axis; and that each of these plane rays, whatever its actual character, is susceptible of analysis into a countless number of rays of definite refrangibility—comprising, so far as has yet been determined, every possible wave-length between the limits named.

plane, so that a section of the beam of light would be represented no longer by a cylinder, but by a flat bar. This modification of light is called polarization, and there are various optical devices by which it may be tested, and the position of the resultant plane detected. For light which has passed through no crystalline structure, and has not been emitted, at a very oblique angle, from the luminous surface, the existence of polarization is usually an indication that it has undergone reflection, and the degree in which it exists, together with the position of the plane of polarization, may afford valuable information concerning the reflecting surface.

(To be continued.)

PENNSYLVANIA'S ANCIENT SEA.

Lecture delivered before the Franklin Institute, Thursday evening, Jan. 5, 1871.

By Prof. Leeds.

(Continued from page 61.)

The theories which we adopted in the first lecture of the course with regard to the formation of the earth's crust, and of the gradual cooling of the surface, make it necessary for us to ascribe to the sea at that time a temperature considerably higher than that which it has at present. Although there were no such fearful paroxysms then as later when the crust had thickened sufficiently to withstand all minor forces, and only yielded to some vast throe which raised mountain chains above the surface, yet its movements, the oscillations of the crust above and below the sea-level, were probably proportionately more frequent. The increased solvent power of the water and the greater frequency of its contacts with the land; both these causes combined to saturate the ancient sea with saline ingredients.

That no fishes swam along these sandy shores may perhaps be better explained or understood in connection with the composition of the sea at the time the beach was forming. For although whole genera of animals and plants have perished, which, probably were as well able to live now as earlier, yet it is certain that no creature was created prior to the existence of those circumstances which made life endurable. Nay, more, in consideration of the perfect adaptation and harmony which we note everywhere between every

animal and its home, it is not too much to say that no creature was developed before its life would be pleasurable to itself, and that too in the highest degree. To my mind, the fact that no fishes existed in this ancient sea, is evidence that the sea then differed from the present ocean. Differed in the great excess of its mineral and the scantiness of its organic constituents. The growth of fishes does not demand a large quantity of mineral matter—their skeletons of bone forms a moiety of their weight and bulk. Indeed, when the earliest formed fishes appear in the sea, they are found to consist largely of cartilaginous skeletons, demanding little if any limestone or other mineral matter. But their fleshy parts were very greatly developed, and demanded for their sustenance an abundance of vegetable and animal food.

Fishes have done very little in the building up of rock strata. Very frequently they decayed entirely or left no sign except the pattern of bony plate, or fin, or spinal column. They are in no sense to be regarded as rock builders or masons. They are consumers, voracious feeders, and many of them scavengers, removing vast quantities of decaying and decayed vegetable matter from the ocean, assimilating myriads of smaller and less highly organized creatures into their own structure, and becoming themselves the food of bird and beast.

The denizens of the ancient sea appear to have been constructed to subserve very different uses. We are impressed on examining them with the idea that their structure was designed to animate the largest possible amount of mineral matter with the smallest possible quantity of organic. Considered with regard to the animals which lived at this time, and not with reference to the rocks which were then formed, this age is pre-eminently the Age of Mollusks—creatures with shells. Shells are the skeletons of animals with soft bag-like bodies, and serve to support and maintain in position the yielding fleshy parts. But note in the first place, that these skeletons are not placed in the interior as they are in animals of higher organization, not divided up into the finest shafts and scaffoldings consistently with the burden which they have to sustain as in the case of fishes, not filled with great cavities and inflated with air as among birds, not permeated by absorbents and blood vessels and charged to repletion with every variety of duct and vessel capable of urging vitality to the highest, such as we find among animals and especially in man. These skeletons are solid, destitute of tube,

chink or cavity. They are thick and massive, capable of withstanding the attack of foes. Fortified with ribs and buttresses and great spines, resisting the thump of the waves upon the shore or the dash of the storm upon the reef. Many have wide thick hinges, and terminate in huge stony beaks. In some of the brachiopods, the dorsal curves in beneath the ventral of the two valves which form the shell, and leaves but a thin disk very small compared with the bulk of the shell itself, to accommodate the body of the animal. In other great families of the brachiopods, such as the terebratula, spirifer and rhynchonella another device for giving support to the flesh of the mollusk is resorted to but one which equally conspires to exaggerate the proportion of the stony to that of the living and perishable part. They are provided with calcareous supports, running into the body of the animal upon the inside, and curved or twisted or bent up into spirals as the case may be.

These ancient seas were prolific in a vast number of shells, resembling the Nautilus, in which the design to which I have alluded is even more apparent. These animals could never cease building, and were compelled to build a new and larger house for themselves with every year of their existence. Every little while came moving day, when they were compelled to move out of their former habitation and close it up by a wall whose only entrance was a little door, through which they thrust down into the hold as it were a tube or siphuncle, by means of which they might load on or throw off ballast, and sail upon the surface or feed upon the bottom, just as they pleased.

The earliest of these chambered shells, or *cephalopods*, as they are called, were stout, strongly-built fellows befitting their craft as masons, and displaying little in the way of decoration or beauty of shape. Many of them were huge, slightly-tapering cones, a foot in diameter at their broadest part, and stretching twelve or fifteen feet behind the head of the animal; an iron-clad monitor, which, if armed like his descendants, the cuttle-fishes, with ferocious mandibles, must have been a fearful craft to contend with. As time went on these cephalopods changed, until from being the most massive of the molusks some of their successors, as, for instance, the paper nautilus are among the most delicate. The straight *Orthoceras* gave place to the *Lituites* with shell curved like the trumpet with which the Romans were wont to summon the legions to battle. And these again to species more and more closely coiled until the ex-

treme of curvature is reached and the coils meet, as in the Nautilus and Ammonite. Instead of the thick straight wall which the orthoceras built against his former dwelling place, his descendants devised every variety of beautiful arch and vault, and substituted intricacy of pattern and complex architectural devices for the cyclopean masonry of their ancestors. At last the shell is taken away from the outside, and as in the case of the modern cephalopods it is put in the interior, the soft parts enclosing it. And instead of being compact limstone, it becomes, as we see in the cuttle-fish, spongy, and in the squid, even horny in its texture.

I shall merely allude to the vast profusion of other rock-building animals at this era, to the enormous number of corallines and the great size and abundance of encrinites or stone lilies as they are called. But I would call your attention more particularly to one of the most curious of the inhabitants of this ancient sea, and ask you to note how well adapted he was to pile up rock masses. I allude to the Trilobite, of which old-fashioned fore-runner of the crabs, nearly sixty specimens have been found scattered over this sandy beach. His remains, indeed, are present in the greatest profusion—a profusion which is indicative not only of the immense number of individuals which flourished in these seas, but, what is more to our present purpose, of the great strength and solidity of the shell and of its adaptation to rock construction. For the question whether a species of plant or animal shall leave behind some fossil relic of its existence depends vastly more upon the materials of which it is composed, than upon the fewness or multitude of individuals. Consider for a moment the countless millions of insects and worms and birds which populate the air and earth and water at the present time, and have filled every corner of the earth with busy hum and motion in ages that have gone before, yet how few of these leave any token behind. But the tribolite was fortified by a massive buckler upon the head, and defended himself against attacks from the rear by a heavy shield. His eyes looked out from loop-holes in watch-towers erected far above his head. Great plates curved backwards over the cheeks and sheltered his flanks. Young and old, little and big, in every attitude of eating, repose or war, lying prone upon their backs, rolled up into balls so as to bring their tender organs of locomotion within the ramparts of their stony covering, in every stage of embryonic growth, and every period of

prime and decrepitude, trilobites here, trilobites there—these sea-coast rocks are full of them.

In some places these grave-yards of the dead of the ancient sea-dwellers have remained undisturbed, and not even the trinkets of Pompeii and Herculaneum, or the jewels found in Etruscan vases, are more perfect than their every limb and plate. Elsewhere coral, shell and crinoid have been crushed into fragments triturated to dust and compacted into rocks over which we may wander for hundreds of miles, and quarry downward through as many feet, without detecting point or line which may make the vast tomb-stone legible. And if we shrink back appalled at the thought of such utter havoc and destruction, what explanation more comfortable or more reasonable can suggest itself?

Does it help the matter at all to take the consideration of the origin of these limestone rocks away from the naturalist and turn it over to the chemist. To regard these ancient seas not as aquaria, but as precipitating vessels—their contents not as coming from the charnel house, but as refuse thrown from the laboratory of nature. We know, indeed, of springs laden with calcareous matter, such as are found in England and in Italy, such as deposit around their sides coats of limestone, and speedily incrust the birds'-nests and toys that tourists carry away with them as curiosities. But will any number of springs which we might imagine to have opened out upon the bottom of the ancient sea, account for limstone rocks spreading over thousands of miles and of prodigious thickness. And if we attribute the formation of these limestone rocks to evaporation and precipitation, we are compelled to suppose in the first place that these seas were divided by barriers into land-locked basins, and, secondly, that they were so charged with calcareous matter and so deficient in common salt and other saline ingredients that beds of limestone would be formed by precipitation on the bottom unmixed with any of the other numerous chemicals which the seas usually contain.

I have previously spoken of the rapidity with which the coast-line of the ancient sea altered. Limestone succeeds sandstone and sandstone follows shale, and shale is succeeded by limestone again, each kind of rock telling us that a change had taken place in the sea-beach, in the sea depth and oftentimes in the marine plants and animals just prior to the beginning of its deposition. The cold currents from polar regions probably streamed at this era along the

shores of Labrador, New England and probably much further southward. No vestige of reef or barrier along the southern shore remains to render improbable the supposition that the warm ocean streams flowing upward from the equator found their way in this ancient continental sea, tempering and diversifying its climate, and that a primeval gulf stream carried warmth and life to the westward of the Appalachians as now the present gulf stream makes Ireland verdure-clad and Norway habitable. Where the waters were shallow and poured along impetuously, beds of coarser sand and pebbles and gravel were formed. Tranquil bays and greater depths were filled up by fine silt, and were tenanted by brachiopods and other animals, akin to mussel and oyster, that love a muddy bottom. Far out in the open seas, where lines of hill or crater of old volcanoes gradually sinking beneath the surface, or reefs lying beyond the overturning and filth of surge and breaker, in waters pure as those that now lave the atolls of the mid-Pacific or boom along the shores of the Philippines, myriads of polyps plied their self-denying craft. If we could have looked down through waters where such corals grew we should have seen parterres of many shaped cyathopylloids, corallines with the tiniest of cups and vases, looking like the calices of slender flowers. To heighten our enjoyment among these gardens of the sea and to complete the illusion we should have seen crinoids great and small. Some standing on slender stems and others on stout trunks—stems and trunks round, five-sided and many-sided, stems smooth, chanelled, punctured, spined. And as stem and trunk bent or waved to and fro with current and with tide, the stony boughs above rose and fell with their motion. A thousand tentaculæ spread out their tendrils to drink in food and life from the sea.

As empires and dynasties have flourished long, until they seemed firmly rooted in the land, yet growing effete or completing their mission have yielded to hardier races, so among the tribes of plants and animals which we have been considering. There came a time when the ancient dwellers along the sea-beach disappeared, and new tribes ruled over sea and land. When the sandstones ceased forming, the denizens of the strand perished too. A time came when limestone was the dominant, as sandstone had formerly been the prevailing rock material. You can study this for yourselves along the gentle slopes and basin of the great Chester Valley. You can see these long fences built of sandstone, and spring-houses

vaulted with thin broad slabs, and houses and churches erected out of the hardened sand which was the first deposit along the shores of Pennsylvania's ancient sea. In the centre of the valley is everywhere limestone. And if we wonder why these slabs and marbles show few if any traces of the life which once teemed among them, their defaced and mutilated condition gives us a sufficient answer. For these sandstones and limstones that once lay almost if not quite horizontal at the bottom of the sea are now tossed up in sharper waves and crests than we see upon the tempestuous ocean. The sand has been compacted into a glassy mass, the limestone has been converted into crystalline marble. And sometimes, as in the deep quarries at Oaklands, whence the columns of Girard College were procured, after a deep trench has been cut upon one side of a bank of marble, and a long line of wooden wedges has been partly driven in along the bottom, a deafening report like a sudden crash of thunder bears witness to the pressure to which the marble has been subjected for centuries, and the sudden relief of which has caused the explosion. Every long furrow up and down the valley indicates a depression between two such uptilts of the limestone strata. Every knoll or grassy hill of a fold in the rocks higher than others in the vicinage. Terrible have been the deluges which have poured down the southern slopes of the North Valley hills and carried along the crests of the waves of the rocks. Down all the hillside and extending far out into the middle of the valley are blocks of sandstone of such weight and size that nothing short of herculean force could have availed to effect their transportation. The limestone crests have been carried off, too, as the rounded and water worn rocks show, but their more perishable nature as compared with the sandstone has brought about their early destruction and disappearance.

If now we should leave the shores of Pennsylvania's ancient sea, and sail across the Atlantic, we should find a Europe still more unlike the present at this period, than was our own North American continent. Germany and France, Great Britain and Spain are marked only by a few and widely remote islands. Italy and Greece. the first civilized of the countries of Europe had not risen from the Mediterranean. Norway and Sweden probably the last inhabited portions of Europe, were then the only parts complete.

And now farewell to the ancient sea. If aught in our ramble along the shore or sail across its waters has interested you, perhaps, you may turn with me at our meeting, next Thursday evening, a curious eye upon Earth's Wrinkles and Faults. And that you may not fail to see them plainly, I shall endeavor to have a number of them photographed for you.

OBSERVATIONS ON FLUORESCENCE.

By Henry Morton, President Stevens Institute Technology, Hoboken, N. J.

I was led to observe recently, that the common asphalt used in many of our pavements gave, with alcohol, a faintly yellow solution, which, in a Geissler tube, fluoresced with a clear blue tint, resembling that obtained from the usual acid solution of quinine-sulphate, though less bright and that with turpentine the same substance formed a solution of a dark orange or mahogany tint, which under like conditions gave a green fluorescence like that observed with the tincture of turmeric, but much brighter.

It occurred to me that the green color in both these last named solutions might be due to the absorbing power of the colored liquid, and I therefore decolorized both by filtering through animal charcoal, when I found in fact that both fluoresced blue. It was of course possible, however, that the filtration had removed some substance which had a green fluorescence, and I therefore varied the experiment by examining the light of the fluorescent substances with the spectroscope. If the green tint was due to a true fluorescence, then an excess of green or yellow light should be found in the body fluorescing green, when compared with one fluorescing blue or with the spectrum of the electric discharge in a part of the tube not covered by the solution. If, on the other hand, the green color were due to absorption in connection with a blue fluorescence merely, then we should expect to find no increase in the green or yellow of its spectrum, but only a diminution of the blue and violet colors. The latter was the effect actually observed, and the conclusion drawn from this was further confirmed by observing the spectrum from fluorescing canary glass, in which the green was of course found to be greatly exhausted in brilliancy.

A further confirmation of this idea was obtained by the simple experiment of looking through a layer of these colored liquids at a quinine tube, when exactly the same tint was observed as was given by another illuminated Geissler tube, filled with the solution in question and placed at one side.

I should therefore conclude that the fluorescence of turmeric and of the solution of asphaltum in turpentine is in fact blue, but gets its green appearance simply from the absorptive action of coloring matter present in the liquid. I have of course assumed that in all

these cases there is a large admixture of white light or its equivalent, in the emissions of the blue fluorescing bodies, such as quinine. This is indeed the case, their spectra, as is well known, being practically continuous between the red and lower violet.

Carrying out the idea suggested by the above investigation, it also occurred to me to examine the solution of nitrate of uranium, whose fluorescence has been asserted and denied with such distinctness by various writers. The solid salt introduced into a Geissler tube fluoresces strongly with an actual development of green light, but the solution fluoresces faintly, and with so little green color in its light, compared with the strong yellow tint of the solution, that I should not hesitate to say that its actual fluorescence is blue, like that of quinine, and that it owes its green tinge to absorption.

I feel sure, also, that the same remark applies to agaric and chlorophyle, though I have not yet had time to examine them with the spectroscope, their fluorescence being so faint as to require special arrangements for its study.

I believe, in fact, that the vibrations excited in at least a large class of fluorescent liquids are alike, and are simply composed of a continuous series covering a large part of the spectrum, but with a predominance of the more refrangible rays.

In connection with the above I may here notice another point. As is well known, a neutral solution of quinine sulphate does not fluoresce; an acid must be added. For this purpose, sulphuric, nitric and tartaric acids act well, with doubtless many others; but hydrochloric acid not only does not act, but destroys the action of the others. We can easily assign a chemical reason for the different behavior of the hydrochloric and what we may call the oxygen acids, but, so far as I am aware, the fact does not seem to have been noticed.

ON THE USE OF HYDRAULIC MORTAR.

[Translated from "Die hydraulischen Mörtel" of Dr. W. Michaëlis, for the Journal of the Franklin Institute.]

By Adolph Ott.

(Continued from Vol. LXI, page 422.)

The finest and most easily decomposable portions of the mass will then have full chance to enter into the possible combinations with the hydrate of lime during the process of mixing; it is true that

they thus lose their effect upon the hardening of the mortar, which is not of any material importance, however, if we consider the actual surplus of hydraulising matter in all pozzuolana mixtures.

After compressing the mortar into the desired forms, it must be exposed to the air, but great care should be taken to prevent its too rapid desiccation through long insolation or other agencies, in order that the reactions can take place more gradually, more uniformly, and in accordance with the principles laid down.

In destroying the damaging action of the quickly hardening particles, and in thus preventing the solidification at too early a period, and before the less accessible parts can begin to operate upon each other, the coherence of the mass is secured beyond all question.

The fine division of the pozzuolana, the effective mixture obtained by the use of the machine, and the degree of density due to the compression effected by it, will constitute a mortar answering all reasonable expectations.

Under the influence of the carbonic acid of the atmosphere the surface becomes, within a few months, sufficiently dense and indissoluble to enable it to withstand the destructive agencies to which it may be exposed after immersion.

One of the most effective means for the preservation of the mortar is to let it harden, and to protect it against water for some time after its having been made. The ancients already knew this, and Vitruvius considers it imperatively necessary to leave the blocks made out of hydraulic mortar exposed to the air for a considerable lapse of time previous to their immersion (Vitruvius Lib. V. Cap. 12); or to leave them buried underground for a long time, so as not to deprive them of the requisite humidity.

Happily, hydraulic mortars are exposed to the lasting influence of the water of the sea in some instances only; because in most cases testaceous animals, sea plants and mud cover its surface in many places, thus affording a most welcome and effectual protection.

But wherever this cannot be counted upon, nothing should be omitted or neglected which may in any measure contribute to the density and solidity of the surface of the blocks. One of the most effectual means is their repeated spreading over with soluble glass previous to the immersion.

The Beton or Concrete (Signium of the Romans)—foundations below the surface of the sea, etc.—Before giving to the reader some of the numerous directions for the preparation of pozzuolana mortars, it is advisable to speak of the hydraulic aggregate which we shall have to mention repeatedly in the course of this article. We mean the beton or concrete, on the origin, the nature and the importance of which the following remarks will be found appropriate and necessary.

The ancient Romans, for their constructions under the surface of the water, very frequently used a mortar, consisting of common hydraulic mortar mixed with fragments of hard stones or rocks. With this substance, which they called signinum, masonry of any chosen

size or form conld be easily constructed. All constructions made with this material may be classed as rough walling with small stones.

Foundations below the surface of the sea were originally constructed by first immersing large rocks or stones, and by then spreading them over with hydraulic mortar, in order to fill up the insterstices between the rocks, and thus to bind them together to one solid mass.

But as it was found extremely difficult to effect an even spreading of the mortar, especially at greater depths of water, the method of mixing the mortar with fragments of rocks previous to its immersion was ere long resorted to, and it was found that a uniformly solid masonry could thus be constructed with comparative ease.

Bélidor says that as the water of the sea is never set into commotion beyond from 4 to 5 meters below the surface, it is most advisable to first immerse small fragments of stones at the bottom, on these larger stones have to be piled up, while the top and the escarpment on the side towards the open sea must consist of the largest possible rocks, which ought to be most carefully laid so as to fit them into one another as much as possible, and bring them into close connexion, for which their irregular form is peculiarly fitted, and may be used with great advantage, provided the work is carefully done. It is advisable to do the work during a calm day, with the aid of skilful divers, who can then plainly discern all objects under the water at a distance of from 2 to 3 meters ; and this is exactly the depth at which the water is in the most turbulent commotion, and where, therefore, the greatest precaution ought to be taken. He continues as follows :

"If it is the intention to erect a regular walled mole on such a foundation made of loosely immersed stones, said foundation should reach up to at least 1½ to 2 meters below the surface of the water; the larger stones should then be laid on with the utmost care. The interstices between them should be filled up with smaller fragments, and the structure thus continued until it reaches to within 1 meter below the level of the sea. The work ought then to be discontinued for the period of one year, in order to allow sufficient time, so that by the commotion of the sea a due settling together of the stones will be effected. After this the construction is to be carefully examined to ascertain whether the foundation is settled satisfactorily, when the surface is levelled at about 1 meter below the water.

"In order to be ready for the commencement of the work as soon as a calm sets in, it is necessary to prepare a large quantity of mortar, consisting one-half of gravel or coarse sand and the other half of lime and red earth from pozzuolo. After a careful mixture of these materials a quantity of small flint stones, of the size of walnuts, have to be added.

"This mortar must be left to dry during 24 hours, when, if sufficiently consistent to be handled with a spade, it is put into moulds, the bottom of which can be opened and closed like a lid. These

moulds are then immersed until within a short distance from the surface of the foundation, so that the thinning of the mortar by the passage through the water is avoided as much as possible. In this manner the entire surface of the rock foundation is covered by one layer of mortar, in order to thus fill up all the interstices which may yet remain. On this layer a quantity of somewhat larger flint stones are thrown and pressed into the mortar with the aid of a rammer, taking care that the flints are evenly distributed over the surface. These alternate layers of mortar and flints have to be continued until the construction has reached to within $0^{m}.{}_{3}$ under low water. The last layer, on which the masonry is to be erected, must be most carefully levelled."

(To be continued.)

Bibliographical Notices.

A Text-Book of Elementary Chemistry, Theoretical and Inorganic. By George F. Barker, M. D., &c., C. C. Chatfield & Co.: New Haven, 1870.

A great want has been felt in our schools and colleges for a text-book on chemistry, which should embody in a well systematized manner the theoretical principles, which have, within the few years just passed, worked so thorough a revolution in Chemical Science. The work just named meets this want most satisfactorily, and will receive a cordial welcome from the teachers of the land. The work is well divided: the first part devoted to the elucidation of chemical theories, we have already commented on; the second treats of the facts of Inorganic Chemistry, which are presented as thoroughly as the size of the work will allow. At the close of each chapter are a series of questions and problems which add considerably to its usefulness.

A Text-Book of Chemistry, adapted to Use in High Schools and Academies. By Le Roy C. Cooley, A.M.: Chas. Scribner & Co. New York.

This book doubtless originated, from that want of a readily comprehensible and thoroughly systematized text-book on modern chemistry, which we have indicated in our comment on the preceding work, and the author, who is widely known both as chemist and instructor, has produced a text-book which deserves to receive extensive introduction. The relation of chemistry to the other sciences is admirably presented. The chapters on the chemical action of light, and the conservation of force are the best we have met with in a work of this kind.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXII.] SEPTEMBER, 1871. [No. 3

EDITORIAL.

ITEMS AND NOVELTIES.

The Stevens Institute of Technology.—In our last number we made a brief general notice of this institution, and promised further details on subsequent occasions, and, in fulfillment of this promise, now proceed to the more minute description of some points likely to interest the mass of our readers.

The Building, of which a front view appeared in our last, is constructed of a hard blue trap rock, with trimmings of brown and grey sandstone. The length of the front or main building is 180 feet, and its depth 44 feet. The west wing is 60 by 30 feet, and the middle wing is 80 by 50. An east wing would render the plan symmetrical, but this has not been erected, as sufficient space for the present needs of the school is supplied without it. With the exception of the middle wing, all these portions have three floors, and a basement, and the aggregate floor space is thus a very little less than one acre, all of which is occupied with lecture rooms, laboratories and workshops.

The entire east wing is devoted to the use of the chemical department, containing an assay room, store-room, analytical laboratory for students, balance room, lecture room, mineral cabinet, also used for blowpipe analysis; special analytical laboratory, for advanced students, and study of the Chemical Professor.

The basement is occupied at its western end by the steam boilers used for heating and running the steam machinery, and by a series of furnaces for metallurgical work, including a small reverberatory furnace, built from drawings supplied by Prof. J. M. Ordway, of the Massachusetts Institute of Technology, through the kindness of President J. D. Runkle, of the same institution. Here are also to be found a forge, crucible furnace and other related appliances.

The eastern end of the basement, as will be seen from the accompanying plan, is occupied as a workshop. Here will be found at E′ a double cylinder engine of 25 H. P. At either side of L (one only being indicated in the plan), two lathes, one of 16 and the other of 10-inch swing, both with back gear and the usual attachments. At P, a planer of 3-foot table, and a small planer of 18 inches table, for light hand work. At M, one of Brown & Sharp's Universal Milling Machines and gear cutters, and in the same vicinity an upright drill and a small punch.

At W′ W′ and F′ are placed machinists' pattern-makers' and carpenters' benches, provided with the requisite attachments and tools.

Within the same room, but shut off by a lattice iron partition, are the reservoirs for oxygen and hydrogen gases, under pressure, holding 100 cubic feet each, and connected by pipes with all the lecture rooms throughout the building.

In connection with the outfit of this machine shop, an Emerson Dynamometer has been provided, by which the actual power consumed by different machines, and in different kinds of work, can be accurately measured. A complete assortment of gauges, squares, callipers, scales, &c., by Darling, Brown & Sharp, have also been provided, so that the students in this department will have every facility for becoming familiar with the exactitude attainable and demanded in modern work.

In our next number we will give some account of the arrangement of the Physical Laboratory, Library, Model Room, and Lecture Rooms for Mechanics, Physics and Engineering, and of the very extensive collection of apparatus, models and specimens which these contain.

Stevens Institute of Technology.

B. Boilers, 70 Horse Power.—Harrison.
B′. Battery Room.
C. Closets.
C′. Crucible Furnace.
E. Entrances.
E′. Engine, Steam, 25 Horse Power.
F. Forge.
F′. File Bench.
G. Gas Furnace for Oxygen.
H. Hydrogen Reservoir.
L. Lift.
L′. Lathe Screw Cutting.
M. Milling Machine.
M′. Magneto-Electric Machine fro Electric Light.
O. Oxygen Reservoir.
P. Planer.
R. Reverberatory Furnace.
S. Sinks.
V. Ventilating Shafts.
W. Wash Rooms.
W′. Work Benches for Carpentry.

BASEMENT.

1

p
tc
u
v

u
o
fı
tl
F
b

p
E
o
o
A
fc
N
r

p

t
h
l

I
s
a
c
p
f
c

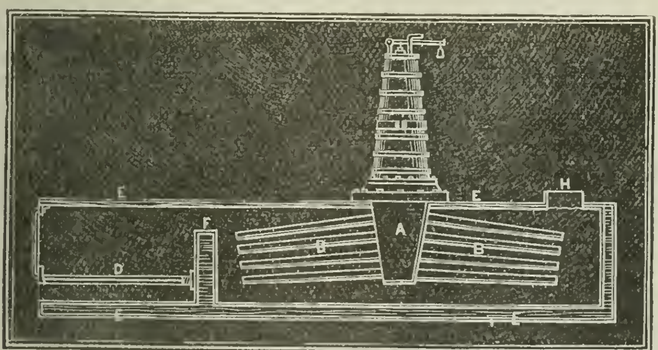
ı
t
є
c

The East River Bridge.—Active operations in preparing for the erection of the East River Bridge have been begun at James' Slip, on the New York shore. The South Seventh Street Ferry has been removed to the next pier above, a new slip and ferry-house built, and wharf repairs made. The old ferry-house occupies about the centre of the space to be used by the bridge, and is now devoted to storage purposes. A number of carpenters, dock-builders and engineers are employed. The elevating engines have been placed in position, and a steam mud excavator at work removing the sewer accumulations from the bottom.

A very substantial platform is being made over the space where the huge caisson is soon to be sunk. Upon this the pumping, hoisting and other machinery will be fixed. Quantities of enormous timbers are used. At least thirty feet of the mud bottom must be taken off before the caisson can be permanently located. In less than a month this introductory task will be finished. Then the foundations of the great pier will be commenced.

An Early American Boiler.—In a recent number of the *Journal* was given a sketch of a tubular boiler, described originally something more than half a century ago.

We here present a sketch of a boiler designed and built by Col. John Stevens, of Hoboken, N. J., and successfully worked, in a small *twin screw* steamer, on the Hudson river, in 1804. A is the



boiler, *b b* the tubes closed at their outer ends, *c* the steam-drum, strengthened with iron bands, *d* the grate, and *e e e e* the outer double casing, filled with non-conducting material; *f* is the bridge-wall, and *h* the opening of the smokepipe.

The original of this remarkable example of early American en-

gineering is preserved, with the boat and machinery, at the Stevens Institute of Technology, at Hoboken, N. J.

That institution has also just received, through the kindness of Commodore Ammen, of the Navy Department, a model of a more recent example of naval engineering—a model of a proposed armored torpedo boat. R. H. T.

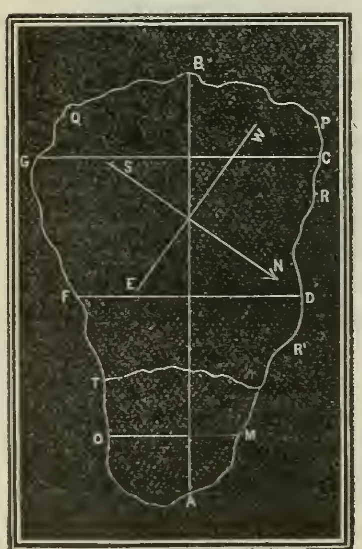
A New Cable is to be laid this summer by a German company. between England and Germany. By arrangements made with the English Atlantic Cable Companies, it will secure all the traffic between America and Germany.

Heating Railway Cars.—On the Kaiser Ferdinand Railroad in Austria, experiments have been made to heat passenger cars with steam drawn direct from the driving engine. The steam is reduced to a pressure of three atmospheres, and conducted by pipes under the seats. The pipes are furnished with cocks, which enable the passengers to increase or reduce the temperature at pleasure. The experiments proved so successful that the directors are said to have ordered all their passenger cars to be similarly heated.

A Huge Boulder.—The accompanying account of a hitherto undescribed and unusually large boulder has been received in a letter from the pen of Prof. Edwin J. Houston. We print it in full.

* * * * * *

The boulder lies at the foot of Bartlett Mountain, near the end of a moraine, about ten minutes' walk E. 31° S. of the Pequawket House of Mr. E. S. Stokes, North Conway, from which I propose to call it the Pequawket Boulder.



The general form of the boulder is that of an irregular parallelopipedon, one of whose longer sides is partially buried. From some cause or other, probably from one of the sides not being properly supported, the mass has fallen into two unequal parts, separated from each other by a space of a few inches. The general outline and dimensions of the upper face may be best seen from the annexed sketch.

The length along the line A B is 52 feet 6 inches. Its breadth

along G C is 21 feet; along F D 16 feet 7 inches, and along O M 10 feet. The length from B to the crack is 37 feet. Where the boulder has fallen apart, the breadth is 12 feet 1 inch. As the sides are almost vertical, the dimensions of the upper and lower faces are approximately the same. The position is indicated by the cardinal points, N., S., E. and W. The boulder is highest on the N. W. and S. W., the other sides, as before mentioned, being partially buried. The height at the point B is 33 feet 2 inches; at P, 28 feet 2 inches, at R, 19 feet 6 inches; at R′, 17 feet 2 inches; at M, 15 feet 3 inches; at A, 9 feet 3 inches; at O, 12 feet 2 inches; at T, 8 feet 5 inches; at F, 10 feet 2 inches; and at Q, 18 feet 3 inches.

The entire mass is composed of a coarse granite, containing a preponderance of feldspar, in rather large pieces, a fair proportion of quartz, and but little mica. Surrounding the boulder are several large fragments, which at one time evidently formed a part of its mass. In front, off the end Q P, there is a mass 31 feet 3 inches long, 15 feet broad, and 21 feet high. On the S. E. side there is another fragment, 31 feet 7 inches long, 15 feet 3 inches broad, and 11 feet 7 inches high. There are also smaller fragments on the other sides.

Several spruces and beeches, thirty or forty feet in height, surround the boulder. Indeed, were it not for these, it could readily be seen from the stage road leading from North Conway to Bartlett, and would, I feel confident, have been carefully described long before this.

A well marked moraine runs up the mountain from the boulder, N. 80° E. I climbed the mountain at this point, following the direction of the moraine by the compass. The moraine is distinctly marked nearly to the summit of the ridge, though the boulders are larger nearer the bottom. About 600 or 800 feet above the Pequawket Boulder they are of considerable dimensions. Several are in the neighborhood of 12 × 13 × 15 feet. A few hundred feet below the Pequawket boulder, in the direction of the moraine, there is another large mass, measuring 31 feet in length, 18 feet in height, and 12 feet in breadth. All these boulders are of the same material. Assuming the boulder to be of the same thickness throughout, a rough estimate would make its weight about 2300 tons.

The rocks of the ridge at this part of the mountain are composed of a breccia, formed of fragments of an argillaceous shale, interspersed through a granite. This, of course, shows the granite to be

of a later formation than the shale. Although no portion of the shale was detected in the granite of the boulder, I think, from the close similarity in the mineral constituents of the two granites, that they were coeval in formation.

I write you hoping to bring this enormous boulder to the notice of a more practical geologist than myself.

Binocular Vision.—It is with pleasure that we are permitted to announce to our readers, that a series of papers on the phenomena of binocular vision will shortly appear in the pages of this *Journal* from the pen of Prof. Chas. F. Himes. The papers will be a thorough discussion of the subject, and will include a review of, and criticisms upon the several theories extant, as well as the results of original research.

Iron Paper.—The *Mining Journal* gives us the following account of what it declares to be the thinnest sheet of iron ever rolled. The mill-manager of the Upper Forrest Tin Works, near Swansea, has succeeded in producing, from iron made upon the premises, a sheet 10 + 5½ inches, or 55 inches in surface, which weighs but 20 grains. When brought to the standard of 44 superficial inches, which previous competition had fixed as a standard of comparison, its weight is but 16 grains, or 30 per cent. less than any sample previously produced. Its thickness is estimated at $\frac{1}{4800}$ths of an inch.

Fuel for domestic purposes, it appears from one of our French exchanges, became so rare an article during the siege of Paris, that several ingenious devices were invented to meet the positive hardship suffered from its scarcity. One process that met with great favor was to saturate porous cylinders of clay prepared for the purpose, with bituminous substances. These were used like the charcoal, which is largely used under ordinary circumstances

A recent Balloon Ascension.—The following account of an ascension, attended with an experience of an unusually interesting nature, has been kindly furnished by Mr. John Wise, member of the Institute, by whom it was conducted.

On the 29th of July last, about noon, the atmosphere over and around Chambersburg, Pa., was more than ordinarily filled with storm clouds. Between the hours of one and three, two thundergusts passed near the town. I delayed the ascent of the balloon, in the hope that a thundergust would pass over us, or at least come near enough to enable the balloon to pass into its central uprising

vortex. Experience has taught me that a balloon, rising from the ground within the sphere of influence of the concentrating air moving from every part of the compass to the storm's vortical centre, will be drawn into that centre, which constitutes its uprising column.

At 3 P. M. a thundergust was approaching us from the north-west, and, with a view of entering it, the balloon was cast loose at 3 o'clock 20 min. The ascent was moderately rapid, and upon gaining an elevation of a thousand feet it was discernible that the storm cloud was passing us too far to the east, leaving the balloon outside of its *drawing-in* influence. It was a mushroon-shaped nimbus, bulged out above and below, trailing its lower ragged edge somewhat behind, and it seemed to labor between contending forces, as it swayed and halted in its onward march. The only great difference manifested now between former experiences and the present one, was the very low temperature of the air we were in. Looking upwards, I saw at a considerably greater elevation an isolated greyish-colored cloud, of an oblong shape, occupying a space of about a thousand acres (I say a thousand acres, because its shadow covered a dozen or more of farms below, and this outline gave me an approximate idea of its dimensions), and it seemed to be quiescent. My attention was now wholly directed to this, to me, new kind of meteor. The cold increased as we mounted up, and much faster than is usual in rising with a balloon. When yet at least a thousand feet below its apparent concave surface and ragged circumference, we entered a fine drizzling shower of snow, which became more copious as we rose towards the cloud, until we reached the point of the most visible deposition, which was equal to a regular snow fall, and as we rose from this point it seemed to diminish in quantity, until we reached the lower surface of the cloud, where it ceased, but we could still see the snow falling below us. While it was at a freezing temperature below, as soon as we had fairly become involved in the cloud, the air began to grow warmer. In the cloud it was not near so dark or dingy as in a thunder cloud, but the light was of a greenish tint. When we emerged from the top of the cloud, the heat, or rather the increase of heat, was sudden, and the sun, shining on our necks and hands, produced an effect I can only compare to the contact of an acid spray, producing a burning sensation.

The cloud just mentioned showed no *bubbling up* upon its sur-

face, as is the case over a thunder cloud, and whatever may have been the action taking place within it, it was of a most placid character. On suffering the balloon to drop down through it, we again encountered the snow—less in quantity, but the cold sudden and intense, and immediately both of us became hoarse, with a painful, irritating sensation in the windpipe, indicating a corrosive action there. May this be the action of ozone upon moist animal membranes? I have great reason to believe that such is the explanation of the fact, as it seemed to me that the mere change of temperature could not produce that marked effect. I may mention, in this connection, that I have frequently experienced the same sensation upon entering a storm cloud.

With these statements my communication will close. I have confined myself strictly to a rehearsal of facts, in order that meteorologists to whom these presents may come, shall be unencumbered in making use of them, should they prove in any sense useful.

The Westfield Explosion.—Previous to holding an inquest, Coroner Keenan addressed a letter to Prof. R. H. Thurston, of the Stevens Institute, Hoboken, desiring him to make a thorough investigation into the cause of the explosion of the boiler of the Westfield, as he wished the opinion of a scientific man to be presented to the Coroner's Jury. Professor Thurston signified his willingness to make the examination, and has been furnished with the necessary authority by the Coroner. During the progress of the inquest, the Coroner retains the Professor as an expert, to assist him in the examination of expert witnesses.

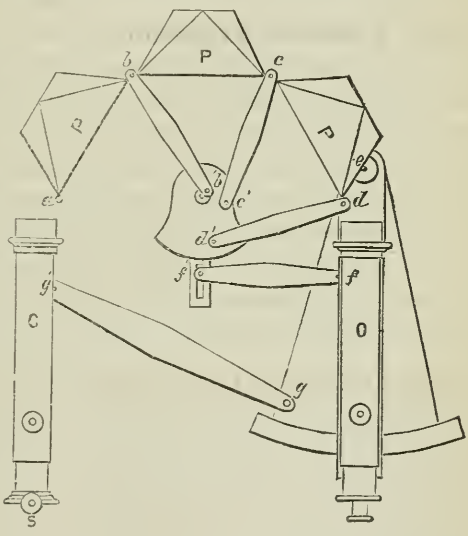
Monochromatic Illumination.—Count Castracane, in a communication to the *Microscopic Journal*, gives some results of his experience with monochromatic light in microscopsy. He declares that the entire absence of chromatic aberration thus obtained greatly increases the defining and penetrating power of the instrument, and strongly recommends to microscopists a more general introduction of the plan. The only essentials are sunlight and a prism; in default of the former, any of the well known means for obtaining a brilliant white light may be resorted to. For the purposes of observation, blue and green are the colors recommended.

A New Light.—In the *Journal l'Eclairage aû Gaz* is given a plan for a new system of illumination. The author, Dr. Harcourt, proposes to mix burning gas with a certain proportion of air, and

to allow the mixture to impinge upon platinum-sponge. The result, it is claimed, is the production of a more brilliant light without increased expense.

Sulphur in Coal Gas.—A simple process of detecting the presence of sulphur in burning gas, is given by Ulex.* It is only necessary to take a clean platinum dish, and evaporate in it about a pint of water, with the gas flame of the Bunsen burner. The outside of the vessel, when examined, will be found to be partly coated with an oily fluid, which can be distinctly shown, by the ordinary qualitative tests, to be sulphuric acid. The white incrustation which makes its appearance on the inside of lamp chimneys, is declared by the same author to consist of sulphate of ammonia, which may also be qualitatively recognized.

An Automatic Spectroscope.—The accompanying engraving represents the plan of a spectroscope designed by Mr. Grubb, to adjust itself automatically to the minimum angle of deviation for the ray under examination.† The design will be found upon inspection to present considerable differences, though essentially the same in principle, to that described in this *Journal*, (LXI. 153) in the notice of the spectroscopes of Messrs. Rutherfurd and Browning. In this, however, the prisms are attached to a central disk, by means of levers



at their points of juncture, and not by their bases. The collimator is stationary, pointing at the centre of the face of the first prism. The arm to which the observing telescope is attached, is united with the central disk in such a way that any motion communicated to it will cause the disk, and therefore the prisms, to fall into the proper position for the examination of any ray.

* Zeitschrift für Anal. Chem. X. 216.

† Quart. Jour. Science, xxx. 270.

Condensation of vapor by changes in tension and temperature.—A very simple and yet effective method of demonstrating the above action has been observed by Mr. Wm. E. Geyer, instructor in Physics and Mathematics in the Stevens High School. If a pipette with a glass bulb about an inch in diameter, is provided with an elastic rubber elipsoid, as when used for tank experiments in the lantern, and is moistened with water inside by being filled and emptied; then if the air is partially expelled by compressing the rubber ball, the point of the pipette closed with the finger, and the rubber released, a cloud at once fills the glass bulb. This is immediately dispersed by renewal of pressure only to reappear on its relief. The pipette should be held between the eye and the light.

Properties of Nitro-Glycerine.—From the researches of P. Champion, published in the *Comptes Rendus*, we are furnished with a very thorough knowledge of the physical properties of this important but dangerous product. The results of Kopp's labors previously published amongst our *Items* list are confirmed and much addditional intelligence is added by the late research. The following abstract may prove useful:—Nitro-glycerine is soluble in ether and alcohol, (above 50° C. with the latter) and totally insoluble in water. It is not liable to spontaneous decomposition when *pure*: and when exposed to a continued cold of —2° C., it is converted into a solid crystalline mass. It is decomposed by fuming nitric and also by sulphuric acids, or by a mixture of the two, thus accounting for the slight variation from the theoretical quantity always experienced in the manufacture of the material (by the action of a mixture of the acids on glycerine).

It boils but does not explode at 185° C., volatilizes rapidly at 200°, deflagrates violently at 257°. At a red heat it assumes the spheroidal state, and is volatilized without explosion; and finally though it explodes with violence by a blow—the electric spark does not affect it.

The American Association for the Advancement of Science.—The twentieth annual meeting of the American Association was inaugurated on Wednesday, August 15th, at Indianapolis, Indiana. The Association receives, on the morning of this day, an address of welcome from the Governor of the State. The meeting is quite largely attended and promises to be one of unusual interest. The retiring President, Dr. T. Sterry Hunt, delivers on the occasion of his retirement an address upon the Origin of the

Crystalline Rocks. The citizens of the town and state are fully alive to the importance of the meeting, in connection with the proper appreciation on the part of their scientific visitors, of their material interests, and have very sensibly made arrangements for their proper reception and comfort. Excursions have been arranged for various places of interest in and out of the state, including, among other things, a visit to the centres of the coal and iron industries, and one to Terre Haute, the citizens of which city have contributed $1000 for the proper reception and entertainment of their guests.

A Substitute for Wood Engraving.—The new mechanical agent, the "jet of sand," has as yet, we are fully convinced, only exhibited a fraction of its possible applications. The latest adaptation its ingenious inventor has succeeded in developing into practical efficiency, is to a peculiar process of replacing the art of wood cutting. The few experiments conducted in this direction have given such promise of success, that we feel justified in predicting for it a most important role in the future of the art it represents. We hope, in our next issue, to be able to present to our readers an engraving produced by the use of the sand-blast, of which we have in our possession some excellent specimens. The process, which we are only at liberty to describe in general terms, consists in bringing upon a suitable matrix a photographic copy of the drawing or engraving which it is desired to reproduce. This is then passed beneath the sand-blast, and the cutting thus obtained. This is finally subjected to the electrotyping process, and any desirable number of copies thus produced.

In connection with the same invention, it may be of interest to mention that it has been successfully applied to the cleaning of brass castings in the establishment of William Sellers & Co., Philadelphia, but more especially to the decoration of marbles and other stones for ornamental purposes, at the works of Mr. Struthers. For this purpose, the blocks are protected with an open design of sheet-iron, or of sheet-rubber, and the steam sand jet directed upon them from a convenient distance.

The Isodimorphism of Certain Compounds.—The fact has long been known that the prismatic crystals of saltpetre possessed almost identically the same angles as those of aragonite; and it is equally well known that the soda saltpetre crystallizes in rhombohedrons scarcely to be distinguished by measurement from those of calcite. The fact that a well cleaned crystal of calcite would grow

when suspended in a saturated solution of the soda saltpetre, was demonstrated as early as 1854, by Senarmont, and the analogous phenomenon of the growth of an aragonite crystal immersed in ordinary saltpetre has been long well known. This curious morphological identity was regarded as being sufficient to warrant the holding of the two nitrates as isomorphous, each with the carbonate upon which it grew. Frankenheim, however, has carried the subject further, and has shown that under certain conditions the potassa salt can be obtained in rhombohedrons identical with those of calcite; thus proving the highly interesting fact, that the nitrate of potassa and the carbonate of lime are isodimorphous. It still remains to be shown that the soda salt can assume the crystal form of the rhombic aragonite to complete the last link binding together this interesting group of compounds. A careful investigation, conducted with this object in view, would doubtless prove successful in determining the necessary, but as yet unknown conditions which would bring about the desired result, while the demonstration of the fact would be of the greatest value in sustaining the theoretical considerations which in this and similar cases point to its probability.

Cyanide of Iodine in Iodine.—Dr. G. C. Wittstein has found in a sample of iodine made in the ordinary way 28·75 per cent. of iodide of cyanogen. In another sample, where the maker had tried to separate the impurity by sublimation, there was found 56·87 per cent. The mode of analysis in both cases was to rub together in a mortar weighed quantities of iodine and metallic mercury, until all the free iodine was combined; to treat the mass with water and weigh the insoluble residue. The loss of weight represents the impurity. When iodine containing iodide of cyanogen is treated with metallic iron, proto iodide and proto-cyanide of iron are formed. The addition of carbonate of potassa precipitates both all the iron and all the cyanogen, and the resulting iodide of potassium is free from cyanogen.—*Dingler's Polytechnic Journal.*

A Sensitive Test for Chloroform.—Hofmann announces* that the behaviour of chloroform towards the monamins, in the presence of alcohol and caustic soda, may be utilized with great advantage to determine the fact of its existence in small quantities, in the presence of other similar compounds. The reaction depends upon the formation of Isonitrile, which can be detected without fail by its characteristic smell. The fluid to be tested is poured into a

* Ber. d. D. Chem. Gesell, III. 769.

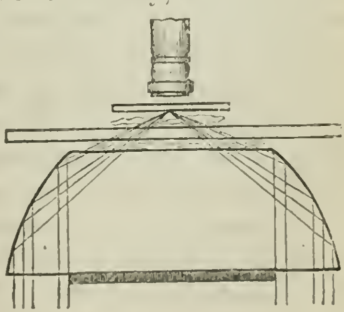
mixture of aniline and caustic soda, when, if chloroform is present, a violent reaction soon sets in, particularly on gentle heating, which is accompanied by the giving off of the characteristic smell of Isonitrile.

New Determinations of Atomic Weights.—Bunsen has recently published* the results of some investigations with a new calorimetric process, which indicate that considerable modification of certain weights and figures must be made, in order to be consistent with fact.

The specific heat of Indium was found to be 0·057. The well-known relation between specific heat and atomic weight, as expressed by the law of Dulong and Petit, furnishes the control by which the correctness of the atomic weight of Indium can be tested. The two values 37·92 and 37·07 heretofore accepted as the nearest approximation to the truth, are found by Bunsen to disagree with the law. It is necessary, according to his results, to assume the formula of the yellow-oxide of Indium to be $In_2\ 0_3$ instead of that heretofore accepted, In0; a process which consists practically in increasing the atomic weight of the metal by one-half. The author announces the value 56·7 for Indium, as most in accordance with his work.

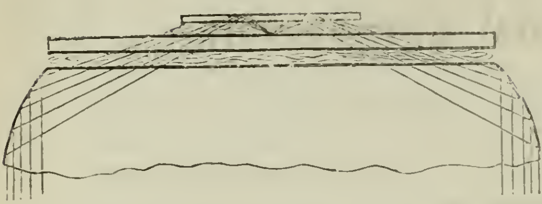
The author has likewise determined the specific heat of Calcium and Ruthenium, corresponding to the atomic weight of 52 for the former and 20 for the latter.

New Devices in Microscopy.—Dr. Barker has communicated to the Royal Irish Academy a new adaptation of the immersion principle for illuminating microscopic objects. The accompanying engravings (for which, as well as for those illustrating the following item, the *Journal* is indebted to the kindness of Dr. William Crookes) illustrates the new device. Dr. B. takes a paraboloid, which, instead of the usual hemispherical cavity, is constructed with a flat top. A thin film of water is also introduced between the paraboloid and the lower surface of the slide; thus securing optical contact between the two. The oblique rays are thus economized, while the liquid film acts as a water-joint, allowing full freedom of motion in the stage.

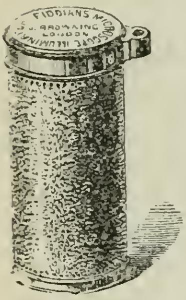


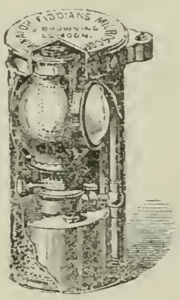
* *Pogg. Annalen.* CXLI. 1.

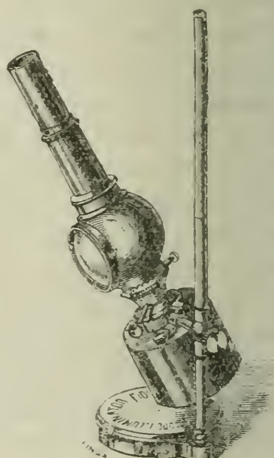
By making the focus of the paraboloid higher the advantage is claimed that the oblique rays will suffer total reflection from the upper surface of the covering glass, so that the object will be additionally illuminated by the reflected light.



A New Lamp for the Microscope.—The *Quarterly Journal of Science* contains, among its miscellaneous notes, an illustrated description of a new lamp, which is here briefly condensed.







The design is that of Mr. Fiddian, and seems to possess several points of advantage. The whole contrivance is intended to be portable, the enclosing case being but 6 inches high by 3 inches in diameter. Its disposition in the case is shown by the second cut. The chimney is of metal, and is jointed so that the parts may telescope into each other. The aperture is furnished with a plano-convex lens to give parallel rays. The appearance of the lamp in operation is shown in the remaining cut. It may be tilted at any angle which may be desired.

Editorial Correspondence.

PHILADELPHIA, July 22d, 1871.

Editor Journal of Franklin Institute.

DEAR SIR—Hearing of the terrible explosion of the locomotive "Vulcan," at Mauch Chunk, on Thursday, I took the train for that locality as soon as possible, but reached the scene of disaster after the forward part of the engine had been removed. This was easily done, for the boiler parted at the rear flue sheet, the forward part of the engine, head-light, stack, bell, &c., remaining intact upon the truck and first two pair of drivers. As far as I could gain information, the rupture of the rear flue-sheet was quite straight across the boiler, and the flues comparatively but little damaged. The whole force of the explosion was therefore in the fire-box, and there the effect was terrible—a total demolition of the rear part of the engine being the only way to express it. The fire-box was rent in pieces, the fractures generally following the line of rivets, but in several cases extending into the sheets, in irregular lines. The heavy braces of the crown-sheet in some cases were torn completely loose, and the whole sheet bent more than double; stay bolts were broken off and scattered in all directions. The accompanying pieces of the fire-box, etc., will give you a fair idea of the general appearance of the whole. Immediately at the fire box an axle connected the hind pair of drivers; this was broken off short against the hubs of both wheels, as if it had been cut by an immense pair of shears. The intensity of the force necessary to produce such an effect can only be imagined. One driver was, it is supposed, thrown into the river, as it had not been found. The tender of the engine was but little damaged. The only effect upon the track was the forcing outward of a couple of rails, and the bending downward and indentation of a third. The latter was evidently under one of the hind drivers; there was an indentation on its face, about 2 feet from one end, $1\frac{1}{2}$ inches deep and 4 inches long, as if compressed by hammering, and the rail bent downwards considerable; the quality of the steel was shown by the fact that there was no signs of fracture.

The worst feature of the explosion is that six men lost their lives by it. They were all upon the engine, and their positions, after the accident, will show the intensity and directions of the forces. The engineer was thrown over 800 feet to the right, up a hill about 100 feet in elevation, and one limb was torn from his trunk; a brakesman was dashed against a bank about 30 feet in the same direction; the fireman was hurled to the left, across the Lehigh river, a distance of over 500 feet, and a brakesman about 150 feet in the same direction. The position of these four and the engine were nearly in a line. The two remaining brakesmen were thrown about 100 feet backward from the engine, and one of them completely stripped of all clothing.

It is evidently strange that the bodies should be thrown, two to the right, two to the rear, and two to the left. The front part of the engine ran forward some 500 feet on the track; but as at the time of the explosion it was drawing a train of cars, this might have partly depended upon the motion of the engine, or the impetus of the train, or a recoil. The cause of the explosion may remain always hidden; for such of the iron as I examined looked good. If, however, it is possible for a boiler to explode by water in a spheroidal form, being relieved from pressure, this may have been such a case. Diligent inquiry among a gang of track layers who were working in the immediate vicinity at the time of the explosion, some of whom were burned or cut by fragments, furnishes the following data.

The engine was slowly drawing a long train of empty coal cars out from a sidling, shortly after passing the gang of hands mentioned; the engineer looked back, and seeing that the hind brakesman had adjusted the switches and jumped upon the train, he gave the engine more steam, and the explosion instantly occurred.

I could gain no other information, for the only description the men in the vicinity could give was that the whole air was full of flying missiles, dust, steam, and burning coal.

Yours respectfully, JOHN BIRKINBINE.

The Sun-Spots.—Prof. Daniel Kirkwood has announced that the period of the sun-spot cycle is gradually lengthening—it being a variable and not a constant figure; and he draws from this fact the conclusion that the cause of this phenomenon is not to be sought in the influence of the planetary bodies, for this influence, being constant, would preclude any variation in its effects; but it must be sought in some purely physical cause operating upon the sun's body.

Civil and Mechanical Engineering.

INTEROCEANIC COMMUNICATION ACROSS CENTRAL AMERICA.

By Prof. J. E. Nourse.

(Continued from page 105.)

M. Chateaubriand, in his youth, was deeply interested in the idea of the northwest passage. He was on the point of going out in person in its search; and when he paid his visit to Washington, he discoursed with him upon this subject with great delight.*

How majestic and fair was Spain in the 16th century! What daring, what heroism and perseverance! Never had the world seen such energy, activity or good fortune. Her's was a will that regarded no obstacles. Neither rivers, deserts nor mountains far higher than those in Europe, arrested her people. They built grand cities; they drew their fleets, as in the twinkling of an eye, from the very forests. A handful of men conquered empires. They seemed a race of giants or demi-gods. One would have supposed that all the work necessary to bind together climates and oceans would have been done at the word of the Spaniards as by enchantment, and, since nature had not left a passage through the centre of America, no matter; so much the better for the glory of the human race! They would make it up by artificial communication. What, indeed, was that for men like them? It were done at a word. Nothing else was left for them to conquer, and the world was becoming too small for them.

Certainly had Spain remained what she then was, what has been in vain sought from nature would have been supplied by man. A canal, or several canals, would have been built to take the place of the long desired strait. Her men of science urged it. In 1551, Gomara, the author of the "History of the Indies," proposed the union of the oceans by three of the very same lines toward which, to this hour, the eye turns with hope.

* The interview is narrated by Chateaubriand—Œuvres Completes, tome xii. The enthusiastic traveler dined by invitation with the President, in Philadelphia, 1791. His enthusiasm prompted him to say to General Washington: "It is less difficult, sire, to discover the passage to the Indies than to create a nation as you have done." But he records in his journal that Washington replied only in French or English monosyllables—probably through his want of familiarity with the French language.

"It is true," said Gomara, "that mountains obstruct these passes, but if there are mountains there are also hands; let but the resolve be made; there will be no want of means: the Indies, to which the passage will be made, will supply them. To a king of Spain with the wealth of the Indies at his command, when the object to be obtained is the spice trade, what is possible is easy."

But the sacred fire suddenly burned itself out in Spain. The Peninsula had for its governor a prince who sought his glory in smothering free thought amongst his own people and in wasting his immense resources in vain efforts to repress it also outside of his own dominions through all Europe. From that hour Spain became benumbed and estranged from all the advances of science and art by means of which other nations, and especially England, developed their true greatness.

Even after France had shown, by her canal of the South,* that boats could ascend and pass the mountain crests, it does not appear that the Spanish government seriously wished to avail themselves of a like means of establishing any communication between her Sea of the Antilles and the South Sea. The mystery enveloping the deliberations of the Council of the Indies has not always remained so profound that we could not know what was going on in that body. The Spanish government afterward opened up to Humboldt free access to its archives, and in these he found several memoirs on the possibility of a union between the two oceans; but he says that in no one of them did he find the main point, the height of the elevations on the Isthmus, sufficiently cleared up, and he could not fail to remark that the memoirs were exclusively *French* or *English*. Spain herself gave it no thought. Since the glorious age of Balboa, among the people indeed the project of a canal was in every one's thoughts. In the very wayside talks in the inns of Spain, when a

* The Canal of the South, or Canal of Languedoc, begun in the reign of Louis XIV., and completed in the year 1668, was the first example in Europe of inland navigation on a great scale, and the most stupendous undertaking of the kind in France. Its general breadth is sixty feet, its depth, six and a half feet. It has 114 locks and sluices, and in its highest part it is 600 feet above the sea level. The canal unites Toulouse on the Garonne with the port of Cette on the Mediterranean. Its cost was 30,000,000 francs, or six millions of dollars. As a scientific work, and as one which called for such an amount of capital, it was an honor to the age that gave it birth.—(See Encyclopædia Britannica, Vol. X.) It is now proposed to enlarge the canal to the capacity of a ship canal, and thus effect a communication between the Atlantic and the Mediterranean, avoiding the passage by Gibraltar.

traveler from the New World chanced to pass, after making him tell of the wonders of Lima and Mexico, of the death of the Inca Atahualpa and the bloody defeat of the Aztecs, and after asking his opinion of Eldorado, the question was always about the two oceans and what great thing would happen if they could succeed in joining them. The Spanish government alone cared nothing for it. For years there was not one publication upon the subject which the humblest of our civil engineers would not now deem beneath his study. It became a mere idea and legend. The long wars of the Spanish monarchy and its fearful decline almost consigned the very idea to oblivion.

In the years 1520 and 1521, Cortez established a rough communication by the route uniting the Chimalapa to the Guasacoalcos. At the end of the eighteenth century, when Spain seemed to wish to awake from her lethargy, there was again some talk of a navigable communication across the Isthmus of Tehuantepec and in Guatemala by the Lake Nicaragua, but nothing of any importance resulted.

In our day, during the war between Napoleon and England, in which Spain was allied to France, the indigo of Guatemala, the most precious of known indigoes came from Tehuantepec by way of Oaxaca on the backs of mules to Vera Cruz for shipment to Europe. The cost of transporting it was thirty dollars per load of 138 kilogrammes; and the muleteers took three months for the journey, which by a straight line is not more than three hundred kilometres. To take this in French measures, it was 3.40 francs for every thousand kilogrammes. Had there been a canal in good order, the expense and time would not have been one-fourth of this.

During the whole of the seventeenth and eighteenth centuries, Spain had great need of the best mode of conveyance across the Isthmus. Yet her treasures from Peru brought by the Spanish galeons to Europe, must always be delayed by the detestable route from Panama to Porto-Belo! So, also, her merchandise from Europe for Panama must go up the Chagres River by miserable boats to Cruces, and from Cruces to Panama on the backs of mules.

Thus little did Spain do in opening up any communication within her domain of the New World. With a good system of conveyance, she might have drawn from her colonies unbounded treasures; for they were so extensive that they were but one-fourth less than half the surface of the moon, and their fertility and riches were yet more

remarkable than their extent. To act as she did in regard to intercourse, and particularly the intercourse between the two oceans, was to falsify her own interests and those of civilization. For if, in the matter of private property, ownership involves the right of neglect or abuse, it is not the same as regards civilization. By the Divine law, there is a right of confiscation against states who do not make use of the *talent* entrusted them by the Master, or who use it against the invincible tendencies to civilization which are promoted by the intercourse of continents and races. This clear law has been too often written in letters of fire and blood on the pages of history to be now possibly called in question!"

Such is the substance of Chevalier's resumé of the old Spanish rule in America, and their neglect of inter-communication between the great oceans. It has been said that the kings of Spain had the will but not the power to accomplish what they desired in this matter: that they depended upon those two old routes,—across Tehuantepec and Panama because their inability to convert them into canals compelled them to accept these. But the most charitable student of history will find himself compelled to agree with the bold protests of Chevalier. He will get the key to the whole Spanish system—to this mysterious closing up or neglect of the highways across the continent from a few paragraphs by another distinguished French author, M. V. A. Malte Brun, son and worthy successor of the great geographer. In his memoir* of a part of the same historic ground, he says,—"The aristocratic nonchalance of the Castilians, and *their fear to open to strangers* by an interoceanic canal the way to the countries they had explored for their own profit only, kept these countries shut up and unimproved. The great events which in Europe occupied Spain in the 17th and 18th centuries, suffered them to consider the rough means of inter-communication sufficient for the age. The court of Madrid, far from encouraging the carrying out of projects for easier and more rapid communication, forbade, on pain of death, the use of the plans proposed. They wronged their own colonies by even falsifying their charts, and representing the coasts as dangerous and the rivers as impassable.

In 1775, several high personages of Oaxaca presented to the Viceroy a memoir proposing to canalize the Guasacoalcos and continue the canal as far as Oaxaca by the Sarabia. An American merchant, Mr. Robinson, in his book on Mexico, tells us that he saw an old copy of this memoir in 1816. Its authors had given the

* Annales des Voyages, 6, ix–x.

topography of the Isthmus, dwelling on its beauty and fertility, and declaring the canal could be built without difficulty. They added, that if political reasons opposed this enterprise, they could tunnel the mountains and thus make another route for the home transportation, which would be available at slight expense. The memoir sent to the Spanish Government was put away in the secret archives, doomed to forgetfulness. An order was issued forbidding the subject *to be mentioned*, except by the Sovereign's permission. The impertinent innovators were censured for proposing such bold revolution within the ordinances for the government of the Kingdom. The Viceroy himself fell under the stern displeasure of the Court, for having seemed to favor the project.

Yet later, Spain fearing the enterprise of other nations interdicted on pain of death the navigation of the San Juan de Nicaragua, built a fort forbidding all access by foreign flags and obstructed the bed of the river by sunken vessels. Not until the independence of the colonies, was an engineer permitted to land on those shores or the great Isthmus to be explored. The governors of the Castle of San Juan were perpetually charged not to suffer an Englishman to reach Lake Nicaragua, for, said they, "if the English ever come to know the value of this country, they will make themselves masters of it."

It is not, however, true that no explorations were made, or knowledge of the Isthmus secured by the Spanish colonies for their own home use. Squier tells us from the Spanish and Mexican authorities, that the continent was traversed and its recesses explored; and that the lines which modern research has indicated as affording facilities for interoceanic communication did not escape the explorers. The south coast of the great Isthmus and the interior of Darien were not thoroughly explored by the Spaniards because of the political reasons already referred to, and because of the hostilities of the Spaniard. The gold mines of Darien increased the political reasons for keeping the country unknown. The errors arising out of the differences of longitude as marked upon the maps were another serious obstacle. These errors in regard to points on opposite sides of the Isthmus, really on the same meridian, misplaced them in some instances as much as thirty miles. Making allowance, however, for want of accuracy in longitude and in the coast lines, we have still reason to believe that the interior was fairly surveyed and mapped. In the valuable collection of documents made by Mr. Arrowsmith, of London, are many Spanish charts,

among which are those that show the Spanish establishments, military and religious, and their mining districts of Darien. "No survey need be better than some of the Spanish works undertaken near the end of the last and the beginning of the first century." Methods of survey and instruments were used by Tofino, Bauza, Cadova and others, which were not adopted until long afterward by English or French surveyors.

In the second edition of Admiral Davis' Report to the United States Senate, 1867, will be found an excellent fac-simile of such an old Spanish map or itinerary, dated in 1781. The Spanish descriptions of the map proved its authenticity, accuracy and value as a military report of that date. It is interesting to observe how the Spanish Governor Ariza only names the "narrow necks of land," which he has discovered, dividing such points as Caledonia on the north, from the Savana on the south or Pacific side. He dared not reveal to Spain a wish for inter-communication to be opened up. The illustrious Humboldt visited the New World as an explorer, arriving in Mexico in the year 1800. He afterward dedicated his great work on New Spain to Charles IV. in grateful acknowledgment for the access granted to him to the Spanish colonies and to the Archives of Spain. In his preface he credits this sovereign with a true interest in securing a knowledge of the colonies. He says: "The time is passed when Spain, through a jealous policy, refused to other nations a thoroughfare across the possessions of which they so long kept the world in ignorance. Accurate maps of the coasts and even minute plans of military positions have been published." Humboldt, throughout his "Essay," urges the Sovereign to the securing of still further geographical knowledge in the New World. He proposes to him the practicability of a canal and discusses the Tehuantepec, Nicaragua, Panama and Atrato routes.

No serious move, however, was made, unless we may except a single proposition made by the Cortez in 1814—a decree which stands in history as the land-mark and link between the old government of Spain and the new, as regards this matter of interoceanic communication. In 1814 the Cortez really authorized and decreed the construction of a canal across the Isthmus of Tehuantepec. But as usual with that august body "they were just in time to be too late." The revolt of the colonies was coming on. Delay *always* belonging to Spanish movements threw the decree forward within the shadow, or rather, the light of the Revolution. The

work was never to be done by Spain. Her day of opportunity was past. The semi-civilization of the Aztecs shows itself in their highways, the remnants of which outlive even the traditions of that people. But their conquerors, though able and wealthy, and possessing the resources of science for a work which would have established their empire and blessed mankind, through their narrow-minded policy added to these highways of intercourse nothing whatever of value.

(To be continued.)

ON THE FLOW OF WATER IN CANALS AND RIVERS.

By D. Farrand Henry, Ph.B.

(Late Assistant on the United States Lake Survey.)

The velocity of water in streams was probably first measured by means of bodies floating upon its surface; and even to the present time, floats are often used to determine surface velocities; although Boileau says:* "One can in certain cases obtain the surface velocity exactly by means of floats; but to obtain this exactitude a great number of often impossible conditions must be fulfilled." And after naming some of the conditions, he concludes (p. 269): "Lastly, even with floats sunk to the surface of the water, it is essential that observations be made in a calm time; for the molecules of a fluid current at the surface are so unstable that a breeze apparently insignificant causes a notable variation in the velocity." And D'Aubuisson, after describing the best kind of floats, says: "In this manner by repeating the operation two or three times, we expect to obtain the velocity of the swiftest current with sufficient exactness; but for the fillets contained between this and the sides, this mode will not answer, the float will not maintain the necessary direction."†

The double float was first constructed by Leonardo da Vinci, (though the idea is attributed to Mariotte.) It was composed of two balls of wax connected by a thread, one loaded so as to sink to the required depth; the other being partly immersed. The objections to surface floats apply with greater force to the double float, which besides has errors of its own which will hereafter be noticed.

* Traité de la mesure des eaux courants, par P. Boileau, Paris. Page 267.

† Treatise on Hydraulics, by J. F. D'Aubuissons de Voisins. Translated by J. Bennett, Boston, 1852, page 156.

In 1777, Mr. T. H. Mann, in a paper read before the British Association, recommended floating rods, loaded at one end so as to sink nearly to the bottom of the stream; the upper end projecting slightly above the surface.

These have been used by Buffon in his velocity measurements of the Tiber; by Krayenhoff in rivers in Holland; and more recently by Mr. J. B. Francis in the Lowell canals. Although more valuable than any other system of floats, they are only applicable to small streams and canals; and even then, many precautions and a large number of observations are necessary to eliminate their unavoidable errors.

The float-wheel which could be held in a current, the velocity being given by the number of revolutions it made in a certain time, is also quite ancient. It was used by Borda and by Dupuit for determining surface velocities.

The latter engineer used a fir-wheel, over two feet in diameter, having on its axle a pinion which engaged with an indexed cog-wheel by means of which the number of revolutions could be directly observed. Woltmann, in 1790, modified this meter so that it could be used beneath the surface. He constructed a helicoidal wheel, with an endless screw on its axle, and a train of two gear-wheels, so hinged to the frame of the meter, that when raised the teeth of the first wheel would engage the screw.

This meter could be run down a pole driven into the bed of the stream, a cord being fastened to an arm connected with the train, so that the gear-wheels could be raised for any required time, and thus the number of revolutions of the meter-wheel recorded. This was a great improvement on the floats, but it is liable to errors arising from the friction of the wheel on its axle, and of the recording train; from the shock the revolving-wheel receives when the train is raised; from the inertia of the gears causing them to revolve after being released; and from the retardation of the train by dirt and vegetable debris suspended in the water.

There is also great difficulty in using this instrument in deep water, as it has to be raised to be read after each observation.

Lapointe raised the recording apparatus above the surface by connecting the axle with a vertical rod by beveled gear. This, of course, obviated the difficulty of clogging the train by dirt, and of raising the meter to read the recording apparatus; but the friction was increased, and the meter could only be used in shallow water.

Baumgarten, Saxton and others have modified the form of this meter, but they have not altered it so as to materially lessen its errors.

Dr. Brewster made the axle of the meter a long fine screw; the hub of the wheel having a female screw cut in it; so that the number of revolutions were indicated by the distance the wheel traveled; and Mr. Laignel modified this meter by fixing the wheel on the screw, and indicating the number of revolutions by a nut which moved an index along a scale. A detent held the wheel in these meters until the commencement of the observations. Although the friction is much reduced in this instrument, the screw could have no great length; and the wheel must be stopped before the full distance is traveled, while the Woltmann meter may be allowed to run more than one revolution of the second wheel of the train.

Mr. Gaunthey, in 1779, invented the pressure plate, which was improved by Brunnings in his tachometer, and used by him on the Rhine; and also by Mr. Racourt in his velocity observations on the Neva. This instrument consisted simply of a disk of metal opposed to the current, the velocity being measured by the amount of weight required to keep it vertical. This meter was further improved by Capt. Boileau; but though it might determine surface velocities with considerable accuracy, it would be very difficult to manipulate in deep water, and as it only shows the velocity at the time of reading, and not the mean of the varying velocities, it would give but little better results than floats. The hydrometric tube, which was improved by Capt. Boileau, is simply a glass tube suspended horizontally in a frame, having a full size opening at one end, and a small orifice at the other. The tube is filled with water, and the large end closed; a small bubble of air being allowed to enter the orifice, and the apparatus is placed in the current, with the small end up stream. Then, opening the large end, the time required for the bubble of air to traverse the tube is noted. The velocity of the stream will be greater than the velocity of the bubble of air by the ratio of the areas of the tube and the orifice.

Besides these meters there have been many instruments proposed for the measurement of the velocity of water, such as Castelli's quadrant, which consisted of a loaded ball, connected by a thread with the centre of a graduated circle, the velocity being shown by the number of degrees the ball was carried from a perpendicular when placed in a current. Dr. Leslie proposed using a thermome-

ter; the temperature of water in motion being higher than when at rest.

Pitot's tube, which was lately improved by Mr. Darcy, is quite an accurate instrument for shallow streams. It consists of two tubes; one of which is drawn to a fine point, and bent at right angles, so that it can be opposed to the current, and the other has a hole of the same size at the lower end. The velocity is shown by the difference of the heights of the water in the two tubes, and by partially exhausting the air from both tubes, the columns of water can be raised high enough to be conveniently read. M. Darcy remarks that it will give an accurate determination of the velocity if the columns be watched for a short time, and the mean taken of the highest and lowest stages.

Among these instruments the preference is generally given to Woltmann's meter, especially in Germany; and if the friction of the parts could be reduced to zero, the danger of retardation by clogging be removed, and if it could be run for any required time at any depth, it would be a perfect instrument for the measurement of velocities.

The telegraphic meter fulfils most of these conditions, and as it was fully tested in the determination of the outflow of the lakes, and has not yet been described in any work on hydraulics, a detailed description will be given.

This meter is shown in Plate I., Figs. 3 and 4, and the register in Figs. 1 and 2; these parts being separate in this instrument.

Fig. 3 is a float meter, consisting of hemispherical cups attached by arms to an axle, which runs between adjustable pivots in a frame B. An independent short arm, C, comes in contact with the fine spiral platinum wire, D, at every revolution of the cups. This wire is insulated from the frame, and is connected with one pole of a magnetic battery, the other pole being connected with the frame, B.

At each revolution of the meter, the battery circuit is made and broken by the short arm coming in contact with the insulated platinum wire. If now a Morse's paper register be placed in the circuit, at each revolution a dot will be made on the moving paper, and the number of these dots recorded in a given time will give the number of revolutions of, and thus the distance traveled by the cups, from which the velocity of the current can be calculated. The ordinary register used is shown in Figs. 1 and 2.

This consists of a Morse sounder, the armature arm, N, being extended, and carrying an escapement which engages with the teeth

HENRY'S
Telegraphic Current Meter

Fig. 1.

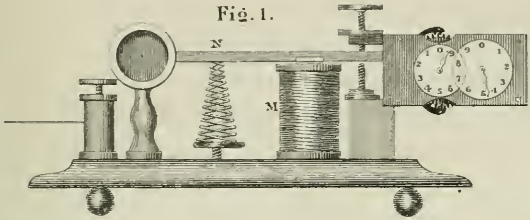


Fig. 2.

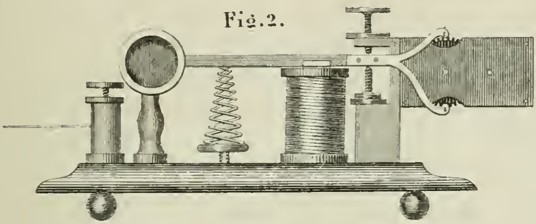


Fig. 5.

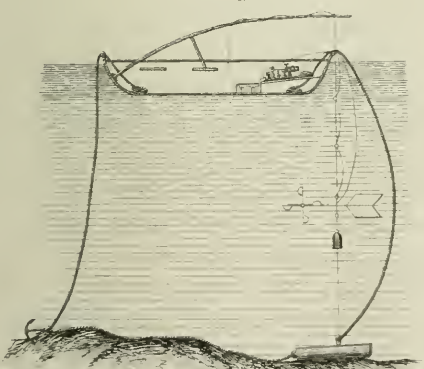
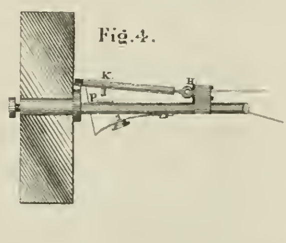


Fig. 3.

Fig. 4.



Drawn by F. Mohtor C. E. Detroit, Mich.

Jas. M^c Guigan Lith. Phila.

of a wheel, G. At each revolution of the meter the armature is attracted to the magnet, M, and the escapement moves forward the wheel, G, one tooth. Any number of wheels can be geared to the wheel, G, so that the revolutions can be recorded for any required time.

Fig. 4 shows another form of meter, the wheel being helicoidal, having an eccentric on its hub, which raises the ivory arm I at each revolution. This arm has a wire passing through it, connecting with the insulated hinge H at one end, and at the other with the platinum point, P. A light spring, S, serves to keep this point in contact with a platinum plate on the axle. The hinge, H, is connected with one pole of the battery by an insulated wire, and the axle with the other pole. At each revolution the eccentric raises the ivory arm, and thus breaks the battery circuit. Both of these meters have vanes at right angles to each other, so as to keep the wheels opposed directly to the current.

The method of using this apparatus is shown in Fig. 5. A boat is anchored in the river at the place where observations are to be made. A lead weight of about 50 lbs., having a strong copper wire fastened to it, is lowered over the stern. This weight is also connected with the anchor by a rope of the proper length to keep it exactly under the stern of the boat. The spring-pole, which runs fore and aft is bent down, and the copper wire fastened to its after end. This serves to keep the wire taut, and also to take up the small motions of the boat. The yoke, in which the frame of the meter hangs, has a swivel ring at top and bottom; to the lower a weight is fastened, and to the upper a measured cord. It has also a spring-clasp which is passed over the wire. The cord has spring clips every five feet, which are also clasped on the wire to keep the cord from bowing down stream. The meter being put on the wire, it can be lowered to any required depth, the wire being connected with one pole of the battery, and the insulated wire, through the register, with the other.

By means of a switch the register can be quickly thrown in or out of circuit, without, of course, affecting or being affected by the revolutions of the meter. In the float meter, therefore, the friction is reduced to that of the wheel on the axle, and the contact of the arm with the fine spiral wire; the register being moved by an independent power, all retardation from clogging the train is obviated; and it can be run for any length of time required.

Co-efficient.—By none of these methods can the velocity be directly obtained; a co-efficient of correction being required. This can be found for meters by drawing them at different velocities through still water; by observing the number of revolutions in currents whose speed is known, and by comparison with other meters and with floats. Some engineers have thought that the relation between the number of revolutions of the meter and the velocity of the current could be expressed by the simple formula:

$v = \text{A} + \text{B}\, n$; in which
$v =$ the velocity of the current.
$n =$ the number of revolutions,

and A and B are constants, whose value must be determined by experiments.

M. Baumgarten and Capt. Boileau found that this relation was best expressed by a slightly curved line.

TABLE I.

Velocity in feet per sec.	Telegraphic Meter, Co-efficient.			Lapointe Meter. Co-efficient.		
	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.
0·3	....	14·573	....	....	....	....
0·5	12·778	12·704	+ 0·074	....	....	....
1·0	11·123	11·190	— 0·067	....	....	....
1·5	10·268	10·300	— 0·032	....	0·650	....
2·0	9·722	9·662	+ 0·060	0·571	0·572	0·001
2·5	9·208	9·208	....	0·546	0·540	+ 0·006
3·0	8·888	8·881	+ 0·007	0·519	0·519	0·000
3·5	8·638	8·686	— 0·048	0·507	0·502	+ 0·005
4·0	8·589	8·546	+ 0·043	0·496	0·493	+ 0·003
4·5	8·504	8·518	— 0·014	0·486	0·485	+ 0·001
5·0	....	....	....	0·477	0·480	— 0·003
5·5	....	....	....	0·474	0·478	— 0·004
6·0	....	....	....	0·466	....	....
6·5	....	....	....	0·469	....	....
7·0	....	....	....	0·473	....	....
8·0	....	....	....	0·469	....	....
Sums...	....	+ 0·015	....	....	....	— 0·007
Mean..	....	+ 0·0017	....	....	....	+ 0·0009

In Table I. are given the observed and computed co-efficients for the telegraphic meter, of the form shown in Fig. 3, and for Lapointe's meter; the observed co-efficients of the latter being taken from Morin's *Hydraulique*, page 100. The co efficient of the latter

was obtained by placing the meter in the centre of a tube between two reservoirs, and noting the number of revolutions made during the time the lower reservoir was being filled.

The observed co-efficient for the telegraphic meter was found by hanging it beneath a boat drawn through still water at different velocities, dividing the distance passed over by the number of revolutions, and grouping the results for every half a foot per second of velocity.

These co-efficients decrease rapidly in the low velocities, and more slowly in the higher. They plot in a curve which approximates closely to an ellipse whose axes are 8·28 and 3·44.

The vertex of the curve is taken at zero of the meter, or the velocity of the current at which it stops revolving. The computed co-efficients in the table are the ordinates of the ellipse, taken at every half foot per second. The difference between these and the observed co-efficients is quite small.

In the Lapointe meter the curve only goes to the velocity of 5·5 feet per second, while the observations were taken up 8·0 feet per second.

The co-efficients beyond the curve differ so little from those at 5·5 feet that they seem to be best expressed by a straight line tangent to the ellipse at that point.

As has been mentioned, the telegraphic meter used in these experiments was made with hemispherical cups, and was, in fact, constructed from a "Robinson's Anemometer.

The ratio of the resistance of a sphere to that of its great circle when drawn through still water is given by Dubuat as 35 to 100; and Beaufoy, with velocities from two to twelve feet per second, made it 342 to 1000.

Robinson's Anemometer was based on these experiments, the velocity of the cups being estimated at one-third that of the wind. Taking the mean of the whole of the above observations, the velocity of the cups is 0·36 of the velocity of the water; but at 4·5 feet per second it is only 0·189; therefore the velocities given by this anemometer are too small when there is more than a light breeze blowing.

The slight difference between the above mean ratio and that found by Dubuat and Beaufoy, shows how little friction there is in this meter, particularly when the resistance of the arms is taken into account; and, in fact, there are no recorded observations of a meter turning at so low a velocity as three-tenths of a foot per second.

(To be continued.)

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. RICHARDS, M. E.

(Continued from page 26.)

IN a previous article in this series, it was stated that wood cutting machines had not received the attention that their importance demanded, and that, as a branch of mechanical engineering, the art had, for some reason, never engaged the attention of our skilled mechanics.

This was some fifteen months since, and now, in that short time, the improvements in wood machines have been such that we would almost ask to reconsider the statement. Perhaps the neglect noted was one of the conditions that now contributes to the rapid improvement in tools of this class during the time. The English scientific journals have, during the past year, devoted more attention to wood tools than at any previous time, and the "art" (in England, at least,) is now in a fair way to reach the point of perfection attained in metal working machines, within a period much shorter than served to give a fixed or standard construction to lathes, planing, drilling and slotting machines, &c.

In fact, time is no longer an element in machine improvement. Experiment is continually giving place to mathematics, and the better understanding of laws that underlie the whole system of machine making and machine adaptation.

The plan was, in these articles, to notice, consecutively, the different classes of wood machines somewhat in the rank of their importance, but improvements have "overtaken us," and it will be necessary to return to the beginning, and notice some band-sawing machinery manufactured by Messrs. Allen Ransome & Co., of London, England, represented in the engravings.

Fig. 1 is a front, and Fig. 2 a side elevation of the mill, drawn to a true scale of $\frac{1}{24}$th. To our engineering friends these very excellent engravings need but little explanation, the several parts being all shown in a clear manner by the two views in flat elevation.

The table, or carriage, is of wrought iron, to secure against danger of breaking in turning and loading logs. The forward feed is graduated from six to twenty feet per minute. The return or gig back motion is constant at eighty feet per minute. The wheels are

WOOD WORKING MACHINERY, PLATE VII.

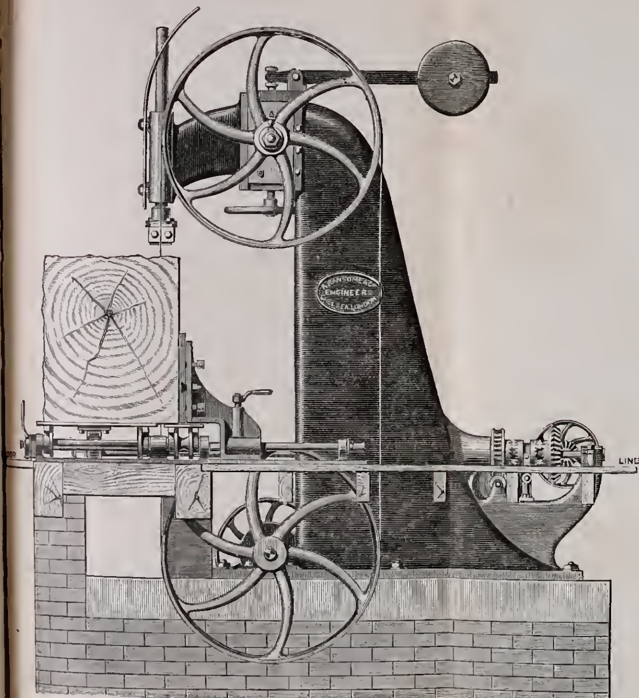


Fig. 1.

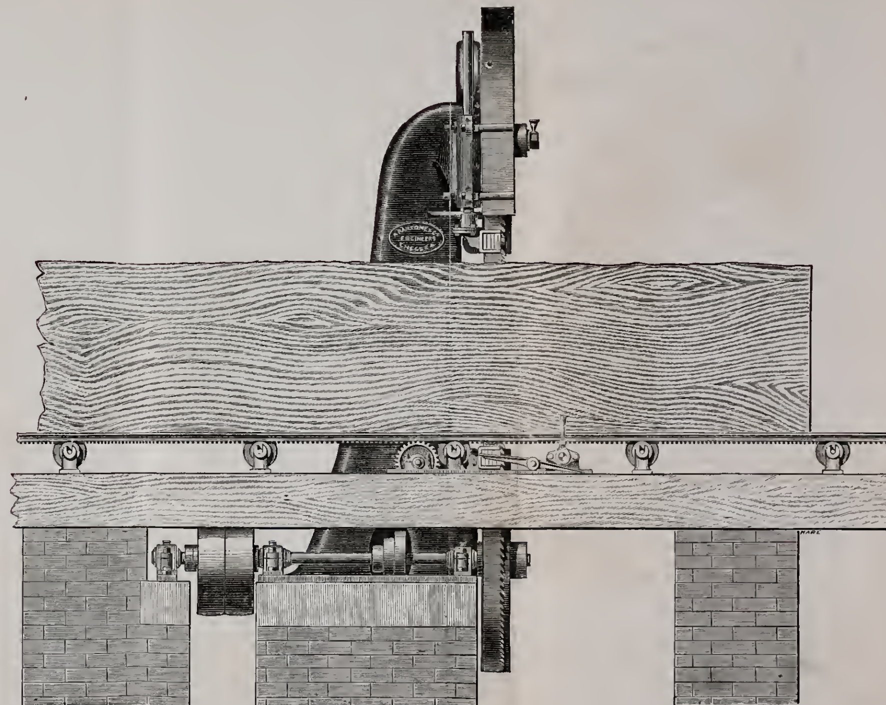


Fig. 2.

A t

]
tin
der
hac
cha

the
aln
wa
prc
ent
to
at
tai
tha
pla

Ex
bet
chi

fer
po
nec
ma
do

a t
cel
bei

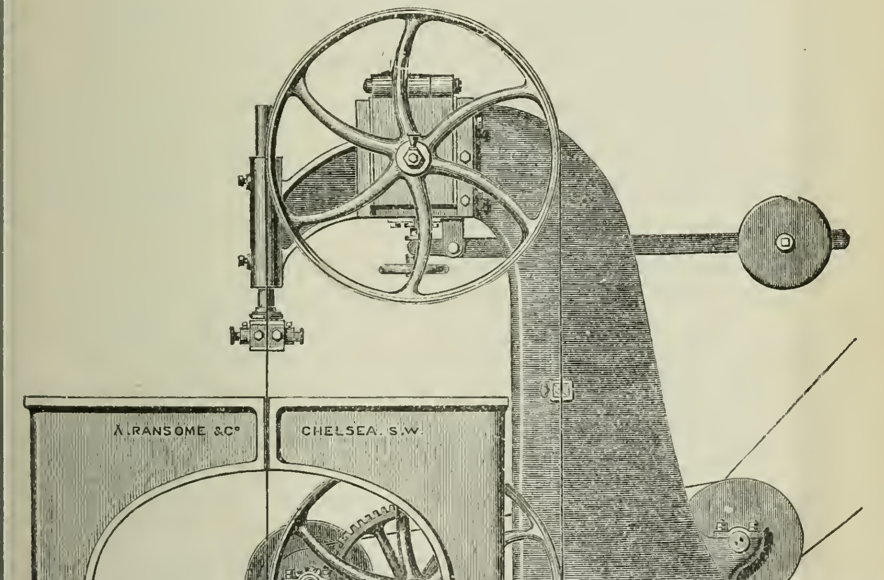
ge
gra
ba

54 inches diameter, length of blades 28 to 30 feet, with a width of from three to five inches; the gauge from 14 to 18 (Birmingham); kerf $\frac{1}{12}$ inch average. The mill receives timber to 36-inch diameter and 30 feet long. The weight is ten tons.

The design is, we need hardly say, a good one. Band sawing machinery requires to be strong and heavy in all parts where rigidity is admissable, especially in all parts that give lateral support to the blades, and in the timber supports. The lineal tension on the blades is regulated by elastic or yielding mechanism, which, in this case, is by means of weighted levers acting on the adjusting screw of the top wheel.

The engraving, Fig. 3, is a true elevation, on a similar scale, of a machine built by the same makers, for "cutting metal," and al-

Fig. 3.



though this use of the band saw is a recent one, it gives promise of high results. A saw can be operated for four hours in iron that is comparatively "clean," without sharpening, cutting from two to three superficial inches of section per minute, or will do twice the same amount in common brass, with a movement of 300 feet per

minute of the blade. The general construction is the same as in the machine shown in the plate at Figs. 1 and 2, with the difference of the reducing gearing seen at the back of the column. The weight is three and one-half tons.*

The manufacture of blades, which has heretofore been confined to France, mainly, at least, will no doubt soon be successfully carried on in England and the United States. The late European war, for a time, so deranged the commerce and manufacture in Band Saw blades, that the manufacture of machines has not progressed so fast as it otherwise might; still, it goes steadily on, and the end of the Band Saw is not yet.

(To be continued.)

BOILER EXPERIMENTS AT THE LOWELL BLEACHERY.

By E. D. Leavitt, Jr., Mechanical Engineer.

The experiments described in this paper were made at the request of F. P. Appleton, Esq., Agent of the Lowell Bleachery, at Lowell, Massachusetts, the object being the determination of the relative advantages of different types of boilers for the service required by that company.

Three varieties of boilers were tried, viz.:

The Harrison cast-iron boiler; the double-flued "Hognose" boiler, known in England as the "Butterly" boiler; and the externally fired, cylindrical tubular boiler, commonly known as the "plain tubular boiler."

An experiment of three days duration was made with each of the two first-named boilers, which was conducted in the following manner, viz.:

1. The coal was carefully weighed.

2. The water supplied to the boilers was measured in a tank that was uniformly filled to a certain height.

The following data were recorded every half hour, from 5 A. M. to 6 P. M., observations being made at intervals of fifteen minutes, and the mean of two observations entered on the record, viz.:

3. The pressure of steam, as indicated by the gauges attached to the boilers.

* The ton, as given in estimating the weight of the machines of Messrs. Ransome & Co. is the English ton of 2240 pounds.

4. The temperature of the steam issuing from the boilers, which was obtained from a thermometer inserted in the main steam pipe, near its junction with the steam-drum.

5. The temperature of the feed-water entering the boilers, taken from a thermometer inserted in the feed pipe.

6. The temperature of the water taken from the tank.

7. The temperature of the atmosphere in the shade.

8. The temperature of the fire room, near the boilers.

9. The force and direction of the wind.

10. The state of the weather.

a. The temperature of the flues leading from the boilers to the chimney was frequently observed.

b. The wood used in kindling fires was weighed.

To insure results that might be depended upon for continuous service, care was taken that all the details connected with the management of the boilers should conform to the usual routine.

There was necessarily considerable variation in the water level of the boilers during the experiments, on account of intermittent feeding, which the tank measurement rendered unavoidable; it is not probable, however, that much, if any loss of economy resulted from this fact.

Fresh fires were started every morning during the experiments, which were burned out after the day's work was done; the furnaces being cleared of their contents of ashes, clinkers and unburned coal during the night.

Boilers operated in this manner will not give as high evaporative results as those that are worked continuously night and day, or those in whose furnaces the fires are banked at night. It was stated that the plan followed had proved the most advantageous for the company, it being necessary to have the best of clean bright fires to meet the demands for steam in the early part of the day, and personal observation during the experiments was confirmatory of the statement.

Care was taken to observe whether the steam supplied by the boilers was dry or charged with moisture; it was impossible, however, to reach a satisfactory conclusion on this point. There were evidences at times of the presence of water in the steam drum of the Harrison boilers, and the steam thermometer attached to the flue boilers indicated an average temperature of $6\frac{1}{2}$ degrees below that due to the average pressure as given by Regnault's tables; this

was in a measure accounted for by the fact that the steam-pipe in which the bulb of the thermometer was inserted was too small to transmit the volume of steam (generated by the flue boilers) without considerable wire-drawing; while the steam gauge was connected directly with the steam drum, and probably indicated a somewhat higher pressure than was contained in the pipe.

In the experiment with the tubular boilers the steam generated by them, together with that from six other boilers, was used by an engine of 400 H. P., the action of which gave no evidence of the passing over of water with the steam.

The steam thermometer attached to the Harrison boilers was broken by water the first night of the trial; the first day's record gave a mean temperature $5\frac{31}{100}$ degrees above that due to the pressure according to Regnault's tables. It is not certain that the thermometer was correct, as it was not compared with the standard previous to the trial, and its breakage precluded any such comparison subsequently.

The Harrison boiler experiment commenced at 6.30 A. M., September 13th, and ended at 6.30 A.M., September, 16th, 1870.

The Flue boiler experiment commenced at 6.30 A. M., September 20th, and was concluded at 6.30 A. M., September 23d.

A summary of the results obtained, together with the leading dimensions of the boilers, arranged in parallel columns for comparison, is as follows, viz.:

SUMMARY, ETC.	*Harrison Boilers.*	*Flue Boilers.*
Date of experiment..................1870	Sept. 13th to 16th.	Sept. 20th to 23d.
Duration of experiment..................	3 days.	3 days.
Number of boilers tried.................	2	3
Size of the boilers	50 H. P.	4 ft. dia.x30 ft. long.
Aggregate H. P. of boilers tried......	100 H. P.	100 H. P.
Total grate surface of "	92 sq. feet.	48 sq feet.
" fire " "	1500 sq. feet.	948 sq. feet.
Ratio of heating surface to grate surface......................................	28·85 to 1.	19·75 to 1.
Mean pressure of steam observed....	60·9 lbs.	63·32 lbs.
Mean temperature of steam (Fahr.) observed..................................	*313·31°	303·69°
Mean temperature of steam (Fahr.) by Regnault's tables, for the pressure observed..........................	308·03°	310·2°
Mean temperature of water in tank	67·27°	65·86°
Mean temperature of feed water entering boilers..............................	144·91°	135·89°
Mean temperature of the atmosphere in the shade..............................	70·22°	65·85°

* One day.

SUMMARY, ETC.	*Harrison Boilers.*	*Flue Boilers.*
Mean temperature of fire room.......	91·93°	93·09°
Direction and force of the wind......	Variable and Light.	Variable and Light.
State of the weather.....................	Fair.	Fair.
Total quantity of water evaporated during trial, in pounds...............	116604	99687
Total quantity of coal consumed during trial, in pounds...............	16125	14187
Ashes and clinkers in the coal, lbs....	1552	1284·5
" " " " per ct.	9·62	9·04
Water evaporated by one pound of coal, from temperature of feed, lbs.	7·23	7·03
Equivalent evaporation from and at 212°..................... pounds	7·95	7·8
Relative economy of the boilers......	101·9	100
Relative quantities of water evaporated by the boilers in equal times or steaming efficiency................	117	100

The temperature of the flue leading from the Harrison boilers varied from 299° to upwards of 600°; the heat was sufficient to break a thermometer graduated to 620° on the first day of the experiment, and subsequently to melt lead.

The temperature of the flue leading from the Hognose boilers ranged between 310° and 510°; usually 420° was the highest indication.

Neither set of boilers had a first-rate draft, and one seemed to operate against the other, so that the ash-pit doors of the Flue boilers had to be partially closed most of the time.

The coal used during all the experiments was Cumberland of excellent quality, burning clean and clear, with less than ten percentum of incombustible matter.

For the purpose of comparison with the results obtained from the experiments made with the tubular boilers, February 17th and 18th, 1870, a corresponding set of experiments were made with the Harrison and Hognose boilers, as follows.

At or soon after the commencement of work on the morning of each day (that the boilers were under trial) the fires were carefully examined and their condition noted. Late in the afternoon the fires were brought to an equally good condition, (as far as careful observation could determine) and the interval between the observations was taken for the duration of the experiment.

The data for these experiments were (in the case of the Harrison and Hognose Boilers) obtained from the daily record referred to at

the beginning of this paper; these experiments being carried on simultaneously with those first described. In the tubular boiler experiments the only data recorded were the weights of water and coal, the temperature of the feed water and the pressure of steam. The weather at the time was cold and stormy, with strong winds, so that the outward circumstances of the trial were not as favorable as in the case of the other boilers.

The results obtained from these experiments stand as follows, viz.:

Type of Boiler.	*Harrison.*	*Hognose.*	*Tubular.*
No. of experiments tried	3	3	2
Aggregate duration of experiments, in hours	24·87	26·25	18·5
Mean pressure of steam, in pounds	62·78	64 89	63 43
Mean temperature of feed water	145·08°	134·49°	69·87°
Pounds of water evaporated	88164	79008 6	92586·6
Pounds of coal burnt	9502	8730	9195
Water evaporated by each pound of coal, from temperature of feed, in pounds	9·28	9·01	9·98
Equivalent evaporation from and at 212° in pounds	10·2	10·01	11·8
Relative economy of boilers	102	100 1	118
Relative steaming efficiency of boilers	108·35	100	166·2
Coal burned per square foot of grate per hour, in pounds	7·35	7·05	10·51
Water evaporated per square foot of fire surface, per hour, in pounds	2·36	3·19	2·53
Grate surface, aggregate square feet	52	48	48
Fire " " " "	1500	948	1985·1
Ratio of fire surface to grate, square feet	28·85 to 1	19·75 to 1	41·3 to 1

The capacity of the tank was found by weighing the quantity of water that was required to fill it to the gauge mark, the temperature of the water being observed and corrections made for any differences of temperature during the experiments.

The steam gauges were tested at the close of the experiments by the American Steam Gauge Co., and the thermometers by Huddleston, the well known maker, (both of Boston) and corrections were made for each observation recorded to bring it to the standard, as shown by the tests.

In the experiment with the Tubular boilers the gauges were reported correct, having been recently tested. No additional test was therefore made at the conclusion of the experiments.

Cambridge, July 11th, 1871.

ON THE SOLUTION, MAINLY BY THE AID OF GRAPHICAL CONSTRUCTION, OF A PROBLEM IN PRACTICAL HYDRAULICS.

By Clemens Herschel, C. E.

(Continued from page 61.)

Another formula by which to get the discharge after 11h. 10m. A. M., would be (see the longitudinal section of the sluice, Fig. 2,) to consider the efflux as composed of two parts, the first part to be the discharge through the area L h_2, in which L is the width of the sluice, and h_2 the depth of water in the downstream end of it, under a head equal to h_1 (see Fig. 2), and the second part to consist of the discharge of the height h_1 as acting over a weir whose length is L, and with a depth on the weir equal to h_1. In this first trial, the correction of the error named was not made, as the trial was only preliminary, and resulted in the rejection of the assumed cross-section; it was applied, however, in the subsequent trials.

The second trial was made with a cross-section 9 feet 7 inches horizontal by 7 feet vertical, taking again the effective cross-section to be 1 foot less in width, *i. e.*, 8 feet 8 inches by 7 feet, and with the bottom again on grade —4, (see Fig. 2, cross-section 2,) and, starting as before with the opening of the gates at 9 A. M., the water standing on the inside on grade 5·40.

The results of the partial or differential calculations, made in the same manner as previously described, and with the formulæ above given, that is $Q = A \sqrt{2\,g\,h}$ until the water leaves the top of the sluice on the inside, and thence with the two formulæ: $Q = 0{\cdot}315$* $L\,H\,\sqrt{2\,g\,H}$† and $Q = Q_1 + Q_2 = L\,h_2\,\sqrt{2\,g\,h_1} + 3{\cdot}33\,L\,h_1^{\frac{3}{2}}$‡ are given in Table II., and also shown on the diagram, [see Table II.]

It will be observed that it so happens that the two last given formulæ attain precisely the same final result; the gates closing at 3·30 P. M., with the water on the inside standing on grade 2·12.

It might seem then that the trial section just investigated also,

* The co-efficient 0·315 is selected corresponding to that depth on the weir of Table 42 Lesbros' Exper. Hydr., which has the same proportion to the length of the weir used by Lesbros that the depths found in our case bear to the length of our weir.

† H in this formula $= h_1 + h_2$ in the next, for the meaning of which see above.

‡ From J. B. Francis' experiments on weirs without side contraction, and near enough applicable for our case.

TABLE II.

[Upper line-and-dot Curve on the Diagram.]

Time of the beginning of the several intervals or differentials of time: A. M. or P. M.	Hour & Min.	Time of the ending of the several intervals or differentials of time: A.M. or P.M.	Hour & Min.	Height of the water on the outside during this interval from the adopted tidal curve. On grade.	Height of the water on the inside at the beginning of this interval using the formula: $Q = A\sqrt{2gh}$ (a.) On grade.	$Q = \cdot315\ LH\sqrt{2gn}$ (b.) On grade.	$Q = Q_1 + Q_2 = Lh_2\sqrt{2gh_1} + 3\cdot33\ Lh_1^{\frac{3}{2}}$ (c.) On grade.	Difference of level between the water on the outside and inside acting during this interval; the height on the inside having been determined by formula of the preceding column. (a.) In ft.	(b.) In ft.	(c.) In ft.	Mean velocity of efflux during this interval. Ft. per sec.	REMARKS.
A. M.	9·	A.M.	9·	5·40	5·40	Top of the sluice under water.	Top of the sluice under water.		......	......		The tide gates open at this time.
"	9·	"	9·30	5·06	5·40			0 34	......	......	4·677	Inside H. W.
"	9·30	"	10·	4·40	5·32			0·92	......	......	7·693	
"	10·	"	10·30	3·75	5·08			1·33	......	......	9·249	
"	10·30	"	11·	3·17	4·76			1·59	......	......	10·113	
"	11·	"	11·30	2·62	4·39			1 77	......	......	10·670	
"	11·30	M.	12·	2·20	3 99			1·79	......	......	10 780	Max. velocity of efflux.
M.	12·	P.M.	12·30	1·92	3 59			1 67	......	......	10·364	
P. M.	12·30	"	1·	1·80	3·21			1·41	......	......	9 523	
"	1·	"	1·30	1·68	2·87			1·19	......	......	6·621*	At the beginning of this interval the inside water level falls below the top of the sluice.
"	1·30	"	2·	1·60	Water level below the top of the sluice.	2·70	2 63	......	1·10	1 03	6·539	
"	2·	"	2·30	1 51		2·54	2·43	......	1·00	0 89	6·461	Low tide.
"	2·30	"	3·	1·64		2 39	2·26	......	0·75	0·62	6·386	
"	3·	"	3·30	1·87		2·25	2·15	......	0 38	0 28	6·316	
"	3·30	"	4.	2·35		2·12	2·12	......	. ....	......	....	
												Inside L. W. the tide gates close at *beginning* of this interval.

was larger than necessary. Before discarding it, however, it was subjected to a different trial, to wit: to start with the water in the river at about where this left off, the rain and freshet being still supposed to continue. This investigation gives the curve 2′, from which it appears that the gates will open at 10 A. M., the water then standing on the inside on grade 4·27.

Table III. gives the results of the partial calculations for this curve, beginning at 10 A. M., the time of the opening of the gates, as it will not be necessary to repeat the manner in which the first part, the straight line, of this curve was determined. The formula $Q = 0{\cdot}315\ L\ H \sqrt{2\ g\ H}$ alone was used in the determination of the final portion of this curve for which see the diagram.

The result of this trial, then, is that the sluice selected will just about maintain the same low water level on the inside in times of freshet and rain storms for days in succession, and in the times between two consecutive stages of inside low water, the level of inside high water will not attain a greater height than within about 1 foot 6 inches of marsh level. This satisfies all the conditions of duty presupposed and was therefore the adopted size and position for the sluice.

For the sake of completeness, however, the calculations have been made for a sluice having a height of 5 feet 4 inches, and width of 7 feet 6 inches equal 40 square feet in section. (see Fig. 2, cross-section 3,) with the bottom on grade —2·58. The results indicating that this section is too small for our purpose are shown on the diagram by the two line-and-two dot curves 3 and 3′.

As a final result, we have, then, that the diagram and table show on inspection, any and all the principal circumstances attendant upon the proposed drainage under the conditions presupposed, and these of course can be varied to meet any desired requirements.

In certain cases, such, for example, as the drainage of low lying districts of towns along the sea-shore (there are some in this neighborhood thus built on reclaimed marsh) the value of the land may be such that it might be preferable to build larger sluices or more of them, and allow for a smaller area of river-bed, or gathering reservoir behind the same; or it may, in other cases, be advisable to intercept some of the river water or of the surface drainage before it enters the confines of the marsh, thereby decreasing the quantity of fresh water drainage to be provided for. It will readily be seen how these and other projects can be fully investigated and their

TABLE III.

[*Lower line-and-dot Curve on the Diagram.*]

Time of the beginning of the several intervals or differentials of time		Time of the ending of the several intervals or differentials of time.		Height of the water on the outside during this interval from the adopted tidal curve.	Height of the water on the inside at the beginning of this interval using formula:		Difference of level between the water on the outside and inside acting during this interval in feet.	Mean velocity of efflux during this interval in feet per second.	REMARKS
					$Q = A\sqrt{2gh}$.	$Q = 0{\cdot}315\ L.H.\sqrt{2gH}$			
A.M. or P.M.	Hour & Min.	A.M. or P.M.	Hour & Min.	On grade.	On grade.	On grade.			
A.M.	10·	A.M.	10·	4·27	4·27	Top of the sluice under water.	0·	......	The tide gates shut at this time.
"	10·	"	10·30	3·75	4·27		0·52	5·783	Inside H. W.
"	10·30	"	11·	3·17	4·13		0·96	7·858	
"	11·	"	11·30	2·62	3·88		1·26	9·003	
"	11·30	M.	12·	2·20	3·57		1·37	9·387	Max. velocity of efflux.
M.	12·	P.M.	12·30	1·92	3·24		1·32	9·214	At the beginning of this interval the inside water level falls below the top of the sluice.
P.M.	12·30	"	1·	1·80	2·92		1·12	6·646	
"	1·	"	1·30	1·68	Water level below the top the sluice.	2·74	1·06	6·559	
"	1·30	"	2·	1·60		2·57	0·97	6·476	
"	2·	"	2·30	1·54		2·42	0·88	6·401	Low tide.
"	2·30	"	3·	1·64		2·28	0·64	6·331	
"	3·	"	3·30	1·87		2·15	0·28	6·265	
"	3·30	"	4·	2·35		2·03	......	......	Inside low water; the tide gates close at the beginning of this interval.

relative values determined by means of calculations similar to the above.

The solution of the problem as hitherto followed, besides neglecting several means of closer approximation which have been pointed out as they occurred is based on the crude assumption that the tide falls by steps at intervals of half an hour.

By taking the intervals of time sufficiently small, the method already given can of course be made to attain any desired degree of accuracy; but it is not, theoretically, a very perfect, and is a laborious way of reaching the desired end. A more perfect way, theoretically, and, moreover, a practical one, would be as follows; and in this also, the intervals of time may be taken shorter or longer, thereby more or less approaching the true data of the problem; with this distinction, however, that with the method now to be described an interval of half an hour for the partial calculations, will cause the probable error to be found in the data of observation and in the fundamental formulæ [formula (*a*), (*b*), &c.], rather than in the the method of calculation; a further degree of accuracy in the latter is therefore of no use, so long as the data of observation and the formulæ (*a*), (*b*), &c., are not more perfect.

The more exact calculation is as follows: divide the tidal curve into straight lines between the half hour verticals, which is to say, take the tide as falling uniformly during the consecutive half hours. An inspection of the curve will show to what slight errors this will lead. Passing now to algebraic symbols and the calculus we shall have,—in the first place again assuming that the level of the water on the inside remains constant for the half hour,—the head on the orifice of discharge at the beginning of the outflow to increase *uniformly* during the 1800 seconds, from h_1 to h_2.

By formula (*a*) the discharge at any time during this interval will be—

$$Q_y = A\sqrt{2\,g}\;b^{\frac{1}{2}}\,x^{\frac{1}{2}},$$ in which

$b =$ the increase of the head in feet per second.

$x =$ the number of seconds after the time when the head $= o$, that Q_y is taken, $\therefore bx = h$, and the meaning of the other letters is as before.

The discharge for the half hour will be—

$$Q_t = \int_{t_1}^{t_2} A\sqrt{2g}\;b^{\frac{1}{2}}\,x^{\frac{1}{2}}\,dx = A\sqrt{2g}\;b^{\frac{1}{2}}\,\frac{2}{3}\left(t_2^{\frac{3}{2}} - t_1^{\frac{3}{2}}\right), \qquad (1.)$$

t_1 and t_2 being the number of seconds after the time when the head $= 0$, which are requisite for the attainment of the heads h_1 and h_2 found at the beginning and ending of the half hour. It will be more convenient for our purpose to have the formula expressed in terms of h_1 and h_2, which may be done as follows:

$b = \frac{h_2 - h_1}{1800}$ from its definition.

$$t_2 = \frac{h_2}{\left(\frac{h_2 - h_1}{1800}\right)} = \frac{1800\, h_2}{h_2 - h_1}.$$

$t_1 = \frac{h_1}{\left(\frac{h_2 - h_1}{1800}\right)} = \frac{1800\, h_1}{h_2 - h_1}$. Substituting these values in equation (1) it becomes—

$$Q_t = A \sqrt{2g}\, \frac{2}{3} \left(\frac{h_2 - h_1}{1800}\right)^{\frac{3}{2}} \left[\left(\frac{1800\, h_2}{h_2 - h_1}\right)^{\frac{3}{2}} - \left(\frac{1800\, h_1}{h_2 - h_1}\right)^{\frac{3}{2}}\right]$$

which multiplying and dividing by $\frac{h_2 - h_1}{1800} =$

$$A \sqrt{2g}\, \tfrac{2}{3}\, 1800\, \frac{h_2^{\frac{3}{2}} - h_1^{\frac{3}{2}}}{h_2 - h_1}, \quad . \quad . \quad . \quad \text{(A.)}$$

In the case of the "weir prolonged on the down stream side by an open rectangular canal of the same width as the weir," we shall find in the event of a variable depth of water on the weir:

$$Q_t = \int_{t_1}^{t_2} 0{\cdot}315\, L \sqrt{2g}\, b^{\frac{3}{2}}\, x^{\frac{3}{2}}\, dx = 0{\cdot}315\, L \sqrt{2g}\, b^{\frac{3}{2}}\, \tfrac{2}{5} \left(t_2^{\frac{5}{2}} - t_1^{\frac{5}{2}}\right), \text{ and}$$

this by a reduction similar to the preceding one.

$$= 0{\cdot}315\, L \sqrt{2g}\, \frac{2}{5}\, 1800\, \frac{H_2^{\frac{5}{2}} - H_1^{\frac{5}{2}}}{H_2 - H_1}, \quad . \quad . \quad . \quad . \quad \text{(B.)}$$

The use of the formulæ (A) and (b) instead of (a) and (b) will result in a greater approximation to the true results which we will call the *second* approximation; a still greater degree of accuracy could be obtained by taking into account the diminution of the head, respectively, depth upon the weir, caused by the inside water level falling during the half-hour and this will bring into use both formulæ (A) and (B), in the following manner. If

$A_R =$ the proper area between the river banks and $R_t =$ the corresponding rise in feet during the interval, due to the freshet and rainfall.

$\frac{Q_t}{A_R} - R_t =$ the amount in feet that the inside water level will have fallen during the interval $= F$.

After having made the calculation for the one interval under consideration, on the assumption that the inside water level remains constant, that is, that the head varies uniformly from h_1 to h_2, it is to be made again supposing now, which is very nearly correct, that the head varies uniformly from h_1 to $[h_2 - \text{F}]$, which method we may call the *third* approximation. It is not easy to suppose a case in practice with greater accuracy than the just described calculations will give, would be required, and, as before mentioned, should such a case occur a first step towards its solution must be a greater degree of accuracy in the data of the observations and the empirical formulæ to be primarily applied.

As a measure of the change produced in the results by the use of the second and third approximations,—the second implying the use of formula (A), and the third that of formulæ (A) and (B), the curve 2′ of the diagram has been recalculated according to both these methods, and the results have been plotted by points enclosed in circles giving the curves $2'_2$ and $2'_3$; they are given numerically also by the values of the ordinates of these curves as found in Table IV.

TABLE IV.

At		When calculated according to the			Remarks.
		First.	Second.	Third.	
A. M. or P. M.	Hours and Minutes.	Approximation, the water stands on the inside on grade.			
A. M.	10·30	4 13	4·15	4·16	
"	11·	3 88	3·90	3·94	
"	11·30	3·57	3 60	3·66	
M.	12·	3 24	3·27	3·35	
P. M.	12 30	2 92	2·95	3·04	The water stands on grade 3, that is, the sluice is just full, at 12 h. 34 m. in the case of third approximation.
"	1·	2 74	2·77	2 84	
"	1·30	2·57	2·60	2 67	
"	2·	2·42	2·45	2·52	
"	2·30	2 28	2 31	2 38	
"	3·	2·15	2·18	2 25	
"	3·30	2·03	2 06	2·13	

It is but just to say that although the differences of the resultant inside water levels are small in the present case owing principally to the *large* area of river bed as compared with the quantity of fresh water inflow, yet they may be found to differ seriously in other cases, where this area is proportionally smaller.

Boston, March 15th, 1871.

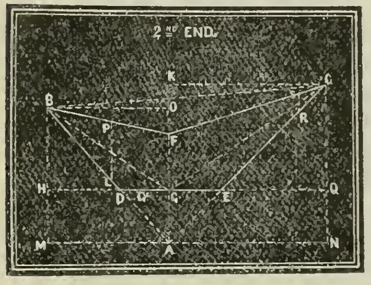
FORMULÆ, RULES AND EXAMPLES OF COMPUTATION FOR SOME OF THE MOST USEFUL CASES OF EARTHWORK UNDER WARPED AND PLANE SURFACES.

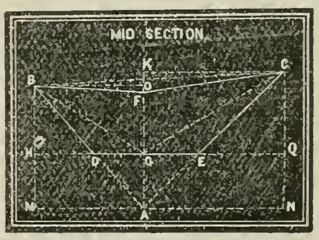
By John Warner.

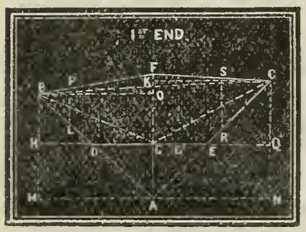
(Continued from Vol. LXI., page 39.)

*Derivation of Formulæ.**—We shall compute by the prismoidal formula, which is—

$$V = \frac{L}{6}(A' + 4A + A'') \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.\dagger)$$







Referring first to the mid cross-section, we consider its whole area to be composed of the areas of four triangles G B D, G B F, G C F, G C E. These areas may be computed together in pairs. Because the two external triangles G B D, G C E, have equal bases G D, G E, they may be computed as one triangle. Keeping this in mind and repeating the same process for each cross-section successively, we shall find—

* The reader will please make the following corrections in the first part of this paper:—Page 397, line 13 from bottom, for distances read distances out; page 399, line 3 and 5 from bottom, for A N read A C; and bottom line, for $_\sigma'$ read $_\sigma$; page 400, line 3 from top, for $_\sigma$ read $_\sigma'$.

† This may be viewed as a particular case of a more general formula, derived by integrating the expression for the differential of a solid generated by the motion of its cross-section. Our formulæ may therefore be derived in a more general manner than is here shown. Macneil employed the prismoidal formula for computing his Earthwork Tables, (1833.) It was prominently brought to the notice of American engineers by Ellwood Morris, C. E., in this *Journal*, Vol. XXV., 2d series, pp. 25, 387; and Vol. XXIII., 3d series, p. 240. It was further discussed in the same *Journal*, by Prof. Gillespie, Vol. XXXIV., 3d series, p. 372, and Vol. XXXVII., p. 11, who, as far as I know, first directed the attention of engineers to the fact that this formula applies to solids contained under a warped surface; and Mr. Chauncey Wright has contributed a mathematical dissertation upon the extension of the formula.—*Mathematical Monthly*, Vol. I., No. 1, p. 21; and No. 2, p. 53. For some further historical notices, see the writer's New Theorems for the Computation of Earthwork, p. 10: H. C. Baird, Philadelphia.

1st end area $GBD + GCE = \frac{BH \times GD + CQ \times GE}{2} = \frac{(BH + CQ) \times GD}{2}$

$$= \frac{(S'_h + D'_h)(S'_b + D'_b)}{8} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

Mid area $GBD + GCE = \frac{(BH + CQ) \times GD}{2} = \frac{S'_h\, S'_b}{8} \quad . \quad (3.)$

2d end area $GBD + GCE = \frac{(BH + CQ) \times GD}{2} = \frac{(S'_h - D'_h)(S'_b - D'_b)}{8}$ (4.)

Performing the multiplications indicated and then applying formula (1), there results after reduction—

Solidity $GBD + GCE = L\,\frac{S'_h S'_b + \frac{1}{3} D'_h D'_b}{8}$, . . . (5.)

If we suppose either pair of end triangles GBD or GCE to vanish, and consequently the solid contained between them, the form of this last equation will not be changed; but the factors $S'_h S'_b$, $D'_h D'_b$, will then represent the sums and differences of the side heights and bases belonging to the remaining pair of end triangles and their contained solid. If the end triangles are dissimilar, the solid will have one or more warped surfaces. If the end triangles are similar and unequal, the solid is a truncated pyramid; if similar and equal, the solid is a prism; if one of the end triangles vanish, the solid is a pyramid. For the prism, D_b' and D'_h vanish, and we have—

Solidity of prism $= L\,\frac{S'_h S'_b}{8}$, ... (6)

For the pyramid the sum and difference of side heights are each equal to the remaining side height, and the same relation exists for the bases. If we suppose GBD to be the remaining end triangle, we shall have by formula (5)—

Solidity of pyramid $= L\,\frac{BH \times GD + \frac{1}{3} BH \times GD}{8} = \frac{L}{3}\;\frac{BH \times GD}{2}$ (7.)

which represents the area of the base GBD, multiplied by one-third of the number expressing the length, and is the usual rule for the solidity of a pyramid.

The solid which has the united triangles GFB, GFC for a cross-section, is computed by a method precisely similar to that employed to derive equation (5), and produces a result entirely analogous. These triangles have the common base GF, with the altitudes respectively, OB and KC. We shall find—

1st end area $GBFC = \frac{GF \times HQ}{2} = \frac{(S_h + D_b)(S_b + D_h)}{8}$, . (8.)

Mid area $GBFC = \frac{GF \times HQ}{2} = \frac{S_h\, S_b}{8}$ . . . (9.)

2d end area $GBFC = \frac{GF \times HQ}{2} = \frac{(S_h - D_h)(S_h - D_h)}{8}$, . (10.)

And from these last three equations we find, by applying equation 1, as before,—

$$\text{Solidity } GBFC = L\,\frac{S_h S_b + \frac{1}{3} D_h D_b}{8}, \quad . \quad . \quad . \quad . \quad (11.)$$

The solidity of the work is found by adding together the solidities expressed by equations (5) and (11), which gives—

$$V_w = L\,\frac{S_h S_b + S'_h S'_b + \frac{1}{3} D_h D_b + \frac{1}{3} D'_h D'_b}{8} \quad . \quad . \quad . \quad (12.)$$

If the width of road-bed is uniform, $S'_b = B$ and D'_b vanishes; equation (12) becomes for this the usual case—

$$V_w = L\,\frac{S_h S_b + S'_h S'_b + \frac{1}{3} D_h D_b}{8} = L\,\frac{S_h S_b + S'_h B + \frac{1}{3} D_h D_b}{8}, \quad (13.)$$

If the solidity of the whole ground between the surface and the intersection of the side slopes be sought, it will be found by formula (11), for in that case we may suppose the road-bed DE to vanish, the point G to fall upon A, and the figure GBFC to become the whole cross-section ABFC. Instead of the centre height GF, we must employ the augmented centre height AF; that is, we must put in formula (11) S_H for S_h, D_H for D_h, and shall find—

$$V_s = L\,\frac{S_H S_b + \frac{1}{3} D_H D_b}{8}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14.)^*$$

If the height GF be not measured in the centre of the road-bed, the solidity may be found by computing separately and then adding the component solids. In the case where the height GF is measured out of the centre, as at G′, but at the same distance and on opposite sides of the centre at the ends, make $GG' = \frac{1}{2} d$. We shall have—

Sum of bases left $= (DG + \frac{1}{2} d) + (DG - \frac{1}{2} d) = S'_b$.

Difference of bases left $= D'_b + d$.

Sum of bases right $= (GE - \frac{1}{2} d) + (GE + \frac{1}{2} d) = S'_b$.

Difference of bases right $= D'_b - d$.

The solidity of the central solid upon GBFC is not altered by the change of the line GF to G′, provided the values of GF and HQ remain unchanged. For the side solids, we shall have according to the method of equation (5), supposing G′ to be joined with B and C,

$$\text{Solidity } G'BD = L\,\frac{S''_h S'_b + \frac{1}{3} D''_h (D'_b + d)}{8}, \quad . \quad . \quad . \quad (15.)$$

$$\text{Solidity } G'CE = L\,\frac{S'''_h S'_b + \frac{1}{3} D'''_h (D'_b - d)}{8}, \quad . \quad . \quad (16.)$$

* For another demonstration, see *New Theorems*, p. 283. The writer's first circulation in print of formulæ (14, 21 and 22) was made, without demonstration and explanation, in a pamphlet published in 1859.

These two united make—

$$\text{Solidity } G'BD + G'CE = L\,\frac{(S''_h + S'''_h)\,S'_b + \frac{1}{3}(D''_h + D'''_h)\,D'_b}{8}$$

$$+ \frac{1}{3}\,\frac{(D''_h - D'''_h)\,d}{8}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (17.)$$

$$= L\,\frac{S'_h\,S'_b + \frac{1}{3}\,D'_h\,D'_b + \frac{1}{3}\,(D''_h - D'''_h)\,d}{8} \quad . \quad . \qquad (18.)$$

Adding this solidity to that of equation (11), we have—

$$V_w = L\,\frac{S_h\,S_b + S'_h\,S'_b + \frac{1}{3}\,D_h\,D_b + \frac{1}{3}\,D'_h\,D'_b + \frac{1}{3}\,(D''_h - D'''_h)\,d}{8} \qquad (19.)$$

In order to compute the volume V of a solid having everywhere a traperoidal cross-section, with a single warped ground surface, as the solid upon B C Q H, we proceed exactly as in deriving formula (5), and shall find a result entirely analogous. We have for every cross-section—

$$\text{Area } BCQH = \frac{(BH + CQ) \times HQ}{2},$$

an expression entirely similar to equations (2), (3) and (4), and requiring, in the formula for the solidity, only the substitution in equation (5) of the sum and difference of the bases H Q instead of those of the bases G D; we have therefore—

$$V = L\,\frac{S'_h\,S_b + \frac{1}{3}\,D'_h\,D_b}{8} \quad . \quad . \quad . \quad . \quad . \qquad (20.)$$

Equation (14) may be transformed by putting $H' + H''$ for S_H, $H' - H''$ for D_H, $\beta' + \beta''$ for S_b, $\beta' - \beta''$ for D_b, we thus find—

$$V_s = L\,\frac{(2\,H' + H'')\,\beta' + (2\,H'' + H')\,\beta''}{12}, \quad . \quad . \qquad (21.)$$

$$V_s = L\,\frac{(2\,\beta' + \beta'')\,H' + (2\,\beta'' + \beta')\,H''}{12}, \quad . \quad . \qquad (22.)$$

The following geometrical considerations apply to the preceding investigations. We have found the area of a triangular cross-section, as G B D, equal to half the rectangle of the base G D and side height B H. The lengths of these lines, on any intermediate cross-section, depend on their initial and terminal lengths, and on the distance between the initial and intermediate cross-section, to which the increase or diminution of base or height is proportional. Hence the area G B D is everywhere independent of the distance out G H, and therefore the volume of the solid generated by the motion of G B D is the same, whatever be the relation between the initial and terminal lengths of G H; but this relation may be such that a warped surface is generated by D B or G H, or both.

(To be continued.)

Mechanics, Physics, and Chemistry.

APPARATUS ILLUSTRATING MECHANICAL PRINCIPLES.

By R. H. Thurston, U.S.N. Engineers, A.A., Prof. Nat. Philos., U. S. Nav. Acad.

Educators seem to have paid comparatively little attention to the illustration of the principles of mechanics by means of specially designed instruments. The catalogues of makers of philosophical apparatus are well filled in the several departments of physics, but display little of value beside the Atwood machine in this department, where the mind of the average student requires most assistance in the effort to seize and retain the, to him, difficult conceptions of the relations of static and dynamic forces.

At the Naval Academy, where, as in other technical schools, a knowledge of the science of mechanics is of the greatest importance to the student, this want has been seriously felt, and Assistant Engineer J. Pemberton, U. S. N., while acting as lecturer on that subject, during the past year, has designed and constructed a considerable number of new and particularly needed pieces of apparatus.

Of these, we select several of the most important for description. The illustrations exhibit them as ordered for the U. S. Naval Academy, and as about to be built by Messrs. Hawkins & Wale,* at the "Stevens Institute of Technology," under the direction of the designer.

The "parallelogram forces" has usually been found a *pous asinorum* to the beginner, and the "parallelopipedon" has been a stumbling block, not so much in the difficulties of its demonstration as in the conception of the relations between the forces themselves and among their geometrical representatives.

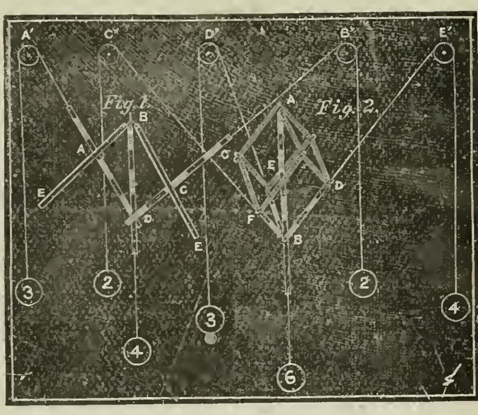
Several attempts have been made to illustrate these problems by means of apparatus, but none have been fully satisfactory.

The Pemberton apparatus as is shown in Figs. 1 and 2.

In Fig. 1 is illustrated the parallelogram of forces. The forces are measured off on the rods A D, B D, C D, respectively, the rods

* Instrument makers to the Institute.

being pinned together at D, and taking the directions of forces acting along the cords carrying the weights 3, 4, 2, as represented, two of them passing over pulleys at A′ and B′, while the third is attached to the lower end of the rod B D. In the special case shown, these weights are 3, 2 and 4. The apparatus now swings into a position of equilibrium, B D becoming vertical.



Laying off upon B D four units of length, it will represent the force 4, and therefore the resultant of the forces 2 and 3, in the directions D C and D A. On the rods D C and D A are equidistant holes, spacing off units of length equal to those on B D. In these may be placed pins to support the lower ends of the light rods B E and B F, which complete the parallelogram, when the pins mark off distances proportional to the component forces.

If, now, either of the weights be changed in magnitude, the figure becomes distorted, and can only be rendered again symmetrical by making corresponding changes in the length of the sides representing the altered forces. The rod B D is telescopic, to allow of such changes.

In Fig. 2 we represent the parallelopipedon of forces in a similar manner.

In this example B F is 2 units in length, B E 3 units, B A 6 units and telescopic, B D 4 units and also telescopic, and all concur at B.

When in equilibrium, the piece B A is vertical, and its length, 6, represents the weight, 6, which is the resultant of the three forces, B F, B E, and B D.

If the principle enunciated be true, the weights being arranged as in the figure, and the weight of the apparatus being taken into consideration as a part of the weight, 6, B A must be the diagonal, and B F, B E, and B D the edges of a parallelopipedon.

To prove this to the student, the representatives of the remaining nine edges of the figure, in groups of three, are so fitted that they may be attached at E D F and A without disturbing the equilibrium,

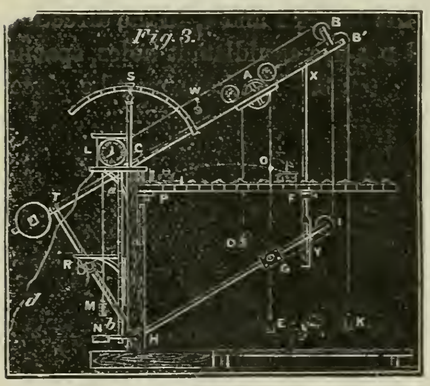
and the parallelopipedon is thus completed. The rods parallel to B D in each of the three sets are telescopic.

Here, again, any one weight being changed, the figure becomes distorted, and is only restored by the restoration of the proportionality between the lengths of the several sides and the magnitudes of the forces which they should severally represent.

With an apparatus in which the rods are made light, and the weights are comparatively heavy, the effect is most pleasing and satisfactory.

Passing by other equally useful and ingenious apparatus added by Mr. P. to our collection, we select, for illustration, a machine by means of which he exhibits the action of the forces of gravity and of projection in giving a projectile its parabolic trajectory.

This consists of a track C B, Fig. 3, movable on a hinge at C, which means of the elevating screw R T and the graduated arc S, can be set at any required "angle of elevation."



The track supports a carriage, A, which carries a pulley, so suspended as to turn very easily. Over this pulley passes a fine wire, or thread, carrying the weights D and E at its extremities. That portion of the cord hanging on the right hand side of the pulley passes through a glass loop, on the guide block G, and carries the ball O, which describes the path of the projectile.

Attached to the carriage are two cords: one passes over the pulley B, thence to a barrel on the clock-work L. This clock is driven by a spring, and runs with a uniform motion, but very much faster than an ordinary clock. The cord, just mentioned, after passing around the clock barrel by which it is driven, hangs downward and carries a weight, M.

The second cord passes from the carriage A over the pulley B′, and sustains a counterbalance weight, K. A third cord passes from W, on the cord L B, over the pulley B, thence to the pulley I and to the guide G, to which it is made fast.

The piece H I is kept parallel to the carriage track B′ C by means of the rod X Y.

The platform N is so connected with the clockwork, through the the rod, *b a*, and a set of levers, that, when the weight M strikes it, the clock will be stopped. The rod *b a* also exhibits a scale of equal parts.

The carriage track having been given any desired angle of elevation, the apparatus is operated as follows:

The carriage is placed at the bottom of its track, at which time the ball O is hidden in or behind the turret of the iron-clad P.

The weights D and E are first made equal, and the clock wound up.

The lanyard *d* being pulled, the clock starts, and carries the carriage up the track with a uniform motion.

Since D and E are equal weights, the ball O will move in a line parallel with C B′, thus exhibiting the trajectory of a projectile acted upon by the force of projection, but freed from that of gravity.

It thus presents the first component of the motion of the projectile under ordinary circumstances.

A small weight, representing the force of gravity, is now added to E, and the ball descends vertically from the elevation just attained, with an accelerated motion, exhibiting thus the second component of the motion of the projectile—that due to the action of gravity.

The carriage is again placed at the lower end of its track, the weight E remaining the greater. On starting the clock, the ball now describes the parabolic path under the action of both components, and falls into or behind the fort F, placed at a distance from P equal to the estimated range.

The motion is so slow that the eye has no difficulty in following it. The *range* is measured on the graduated water line P F. The hands of the clock being placed together at zero, and the weight M adjusted so that it shall reach the platform N when the projectile strikes the fort, we have the *time of flight* registered.

From the time of flight and the distance fallen through by M as measured at the scale *a b*, we may compute the initial velocity; by increasing or diminishing the weight K, we may exhibit the effect of varying the charge of gunpowder, and, in fact, *all* of the circumstances of the motion of a projectile in vacuum may be illustrated, and equations are verified with gratifying precision.

Space will not allow of the description of the apparatus for illustrating the rolling of ships, and the relation of their centers of buoyancy, and gravity, and the metacenter, or to refer to others of these novel, valuable and interesting additions to our mechanical apparatus, for which we are indebted to the peculiar talents of Assistant Engineer Pemberton.

Stevens Institute of Technology, Hoboken, N. J., June, 1871.

ON THE USE OF HYDRAULIC MORTAR.

[Translated from "Die hydraulischen Mörtel" of Dr. W. Michaelis, for the Journal of the Franklin Institute.]

By Adolph Ott.

(Continued from page 144.)

Since Bélidor's time, all mortar mixed in the above mentioned manner is called beton. As will be seen at the first glance, it differs from common hydraulic mortar, inasmuch as gravel and larger fragments of rock are used along with or in place of finer sand. It is altogether indifferent whether these are at once added during the first mixing process, or whether they are subsequently incorporated with the mortar mass, as has been recommended by Bélidor with regard to the larger stones or pieces of rock. The only difference, therefore, which may have existed between beton and concrete, has been long since set aside in practice.

Pasley, according to whom the English first used concrete in 1817, (Penitentiary at Millbank—Robert Smirke) insists upon its difference from beton, inasmuch as it is mixed with smaller stone-fragments like gravel. But, as far as our investigations reach, it would be wrong to suppose that the difference between beton and concrete arises from the constant use of lime of an hydraulic nature, while no water-lime was at first used for concrete.

The great importance of beton masonry is based above all upon the fact that it enables us to construct a very solid foundation wall, as good as if it consisted of one solid piece, even where no quarry stone can be had, and capable of holding off all subsoil moisture or water; besides, it admits of the construction of foundations under water at a considerable depth without requiring the previous drainage of the building ground. All that is necessary is the erection of a coffer dam to protect against the commotion of the water. Even this may be done away with in all cases where artificial stone blocks are used, as the foundation work can be safely constructed by immersing them during a calm, when there is no necessity of any outside protection against the sea, as has been done at the port of Cette.

Although beton was at first used for foundation work only, it has since been made available for construction above water with the greatest success. Indeed, wherever good hydraulic material

can be procured, unusually solid buildings can be rapidly constructed at comparatively little cost. From what we have been able to learn, a French architect, named Lebrun, at Alby, (Département du Tarn) has been the pioneer in this kind of construction, in building a dwelling house on his country seat in 1830, made altogether of beton. The house consisted of a basement with three vaulted rooms, a first story with three rooms, and a vaulted loft or garret.

Mr. Gourlier, in a report to the Société d'encouragement says, that the entire building, even the arcades, the mouldings which serve as decorations of the outer walls, the steps which lead outside from the basement up to the main story, as well as the vaults of the lower story, were all constructed of beton.

Of these vaults or arches, those of the three rooms of the basement have a width of $5^{m}.3$, a height of 1^{m}, and a strength at the apex of $0^{m}.25$. Of the two Roman arches which support the roof, the larger one has a width of $6^{m}.2$, a strength of $0^{m}.25$ at the abutment, and of $0^{m}1.5$ at the crown. Each of the ceilings of the first story is divided into three parts by two beams which are $1^{m}.8$ away from each other; the space between the beams is filled up by a small vault of the height of $0^{m}.15$; strength, $0^{m}.25$ at the abutment and $0^{m}.10$ at the crown.

The beton consisted of:

1 part of hydraulic lime from Alby, slaked by immersion;
1 " clean sand: and
2 " rubble stones of the size of 8–10 centimeters.

The mortar was long and carefully mixed, and was then vigorously pressed down upon the wooden boxes, by means of which the structure was built up in blocks of the height of $0^{m}.3$.

The arcades, arches and vaults were erected on centres, and the mouldings were made with the aid of patterns. The plastering consisted of a thin coat of mortar mixed with sifted sand, which, after being duly smoothed down, made the walls completely even, with polished surface and sharp edges.

During the summer season the mortar had to dry six hours, during the spring twelve hours, when it had sufficiently hardened, and the work could be continued. The centres were removed after from thirty to seventy-five days. The structure proved to be an excellent one, and of undoubted durability, while the cubic meter

of its masonry costs but a trifle more than three-eighths of the cost of brick walling.

We must here remark, that beton mortar has been used on the island of Santorin, since time immemorial, for the construction of cisterns, terraces, vaults, etc. It is said that the terraces which there form the roofing of the houses, are made of a beton substance consisting of:

6	parts of	Santorin earth,
2	"	paste of lime,
1	"	sand, and
8	"	fragments of bricks.

and that the following most simple proceeding is generally resorted to for the construction of vaults: A rough framework is built up and covered with shingles or boards; on these a layer of earth and rubbish is laid, and equalized after a pattern to correspond with the form of the vault to be built over it; then comes a layer of beton, composed of:

4	parts of	Santorin earth,
1	"	paste of line, and
8	"	fragments of quarry stone.

After a lapse of twelve days the framework may be removed with safety.

Since that time the construction of buildings with beton has increased more and more, especially in Denmark and Sweden.

These buildings are erected without any serious difficulty; it is very easy to construct air holes and chimney flues, as well as double insulated walls. The material is such as affords the greatest security against danger from fire; it protects against all external moisture, and secures an almost constantly even temperature in the interior of the building. Whenever wood and building stones are scarce and dear, and where hydraulic materials can be had in abundance, it will be found greatly advantageous to make use of the latter to the fullest extent.

The various experiments made by the Danish Artillery Commission, during a period of ten years, warrant the belief that beton masonry is best adapted to fortification purposes, not only for such forts which are either surrounded by the sea, or situated on the coast, but also for those in the interior.

The splendid sea fortifications in front of the city of Copenhagen are exclusively built of beton masonry, as it was ascertained to be decidedly more bomb-proof than any other kind of masonry.

Beton masonry, while on the one hand of the same solidity with the best bound masonry known, has, moreover, the same peculiarity as loose substance, like earth, inasmuch as shot and shell produce an entirely limited local destruction; this, however, is the principal desideratum for a structure intended to be bomb-proof.

(To be continued.)

THE SUN.

A Course of Five Lectures, before the Peabody Institute of Baltimore.

By Dr. B. A. Gould.

(Continued from page 133.)

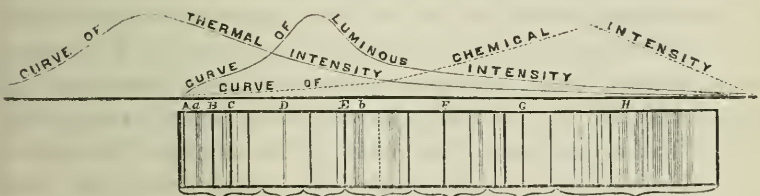
Then the wonderful analysis of light, by the prism, reveals to us in each individual ray of pure white light, in every plane, a myriad of rays, of each intermediate wave length, from the longest to the shortest which the human eye can appreciate. The length of the waves which form any of these ultimate rays manifests itself to the prism by its refrangibility, and to the sense of sight by the impression of color. The longest of the visible waves are the least refrangible—appearing to the eye as red, and having a length of 155 ten-millionths of an inch; the shortest are the most refrangible, and produce the impression of violet—the extremest shown by a common glass prism having a wave length of about 271 ten-millionths of an inch, and all other colors are intermediate between these two. But there are other rays in sunlight more refrangible than the violet, and although our eyes do not usually recognize any of them, and never all of them, they are manifested to us by their chemical action. So, too, there are rays less refrangible than the farthest visible red, and these make themselves known to us as heat. In fact, the length of the solar spectrum producible by a prism is some $5\frac{1}{2}$ times as great as that portion which is perceptible to the eye, by its rainbow tints, and it extends from rays whose undulations are 154 trillion to those in which there are 967 trillion undulations in a second. These various rays of different wave lengths may all be separated and individually examined by a proper com-

bination of prisms, and the apparatus for testing them optically is called a spectroscope. Scarcely ten years have elapsed since discoveries were made which have rendered this a marvelously delicate and potent implement of scientific investigation, with which neither the chemist, the physicist nor the astronomer can at present dispense, and which is rapidly finding important applications in various useful arts.

Thus equipped with the polariscope and the spectroscope, the astronomer finds unsuspected revelations in each ray of light which reaches him from a heavenly body, and these have within a few years largely increased our knowledge of the sun, and rendered our conceptions of his nature far more definite than before.

Few subjects are more fascinating than this of the spectral analysis of light, and it would be an agreeable duty to dwell upon it, and set forth the processes involved, and the gradual, though rapid and still active progress of discovery—to consider the various theoretical inferences suggested by the discoveries already made, and to describe the details of the investigation of sunlight. But this would imply a course of lectures upon this subject alone. I will leave all these points untouched, and simply tell of the results attained. It must therefore suffice to say that when the light from any celestial body is analysed by the prism, a spectrum is produced which is not that of complete white light, but from which the rays of certain special wave lengths are absent. If the beam come to the prism through a very small aperture like a point, its spectrum will of course appear as a line; but if it be admitted through a narrow slit, and a series of spectra thereby formed side by side, one for each point in that slit, it will present the appearance of a long band, of which the width represents the length of the slit, while its length depends upon the power of the prism in separating the rays of different wave-lengths in the original beam, and displaying them side by side. These rays, if concentrated by a lens, would reproduce the original beam; but if again passed through a prism, they become still farther analyzed and displayed. Now, it has long been known that such a spectrum, formed from sunlight, is crossed by a large number of dark lines, each of them corresponding, of course, to a row of dark points—one in the spectrum of each of the several points of light transmitted by the slit; or, in other words, corresponding to a ray of some particular degree of refrangibility which is wanting. The light of the moon and of the brighter planets is

polarized to a considerable extent, but shows the same dark lines as sunlight; thus furnishing independent proof, were any needed, that what we receive from them is reflected sunlight. The light from fixed stars, on the contrary, is unpolarized, and differs from sunlight in its spectral lines; and indeed each star appears to have its own characteristic series of lines, differing more or less from those of any other star. The explanation of these lines is now known, through the brilliant discoveries of Stewart, Angström, and Kirchhoff, who have found that each chemical element, when incandescent at a given temperature, gives off rays of particular wave-lengths, and that these same elements, in the form of vapor, will abstract from transmitted light those very rays which, as incandescent solids, they would omit. Thus the presence of dark lines in a spectrum indicates that the light has traversed some medium which has absorbed the missing rays; and the presence of rays of any particular refrangibility gives token of the nature or temperature of the luminous body whence they emanate. In general, a few bright lines imply a gaseous origin for the light, and point to that particular gas or vapor which would absorb those rays from white light traversing it.



More than this I may not stop to recount concerning the means of inquiry; but these few words may perhaps show to those unacquainted with the nature of spectral analysis, the degree of confidence fairly attributable to its results.

As long ago as 1811, the eminent French philosopher, Arago, tested the different parts of the sun's disk by the polariscope; and from the absence of any polarization in the light from the limb itself (notwithstanding it must come to us from an angle of very great obliquity), he inferred* that the source of sunlight was neither liquid nor solid, but purely gaseous. Subsequent discovery has somewhat modified this conclusion, while confirming its basis—as

* *Mem. Acad. Paris*, 1811, Pt. 1, p. 118; *Kosmos*, III, 395, 418.

will hereafter be seen. And Forbes, in 1836 (before the spectroscope, as we now know it, was dreamed of,) availed himself of an annular eclipse of the sun, when only the margin of his disk was visible, to examine the spectrum then formed. He found* its lines the same in all respects as when the central portions of the disk were visible, and thus discovered that it is only in intensity, and not in quality, that the marginal light differs from that at the centre.

Up to the present time, more than 3500 lines have been recognized in the sun's light, and their positions in the spectrum determined. Of these, a considerable portion, perhaps 600 or 700 in all, is due to the absorptive action of our own atmosphere; another portion, numbering above 800, represents the lines of the 16 metallic elements which I have already mentioned as existing at the sun; the remainder are as yet unexplained. And if we have recourse to other implements of analysis, and examine the heat-rays beyond the red, and the photolytic rays beyond the violet, we find in the lines thus discoverable new fields of research, as yet but slightly explored.

You will not fail to remark that these dark lines signify that the light has passed through a gaseous medium, outside the photosphere, or luminous surface. The existence of such an atmosphere was previously indicated by the comparative dimness of the limb, and it was an essential part of the early theories which required so many envelopes, inasmuch as these envelopes themselves must need support. So, too, if the faculæ are elevations above the general level of the surface, as now seems beyond reasonable doubt, they too imply a supporting atmosphere. But no definite evidence of that refraction which an atmosphere must exert has yet been obtained, so that its density outside the photosphere cannot be very great. Small irregularities detected in the apparent motion of the spots, originally attributed to the effect of refraction, have recently been proved by Faye† to be due to the parallax occasioned by the depth of the cavity; and when the margins, and not the nuclei, of the spots are taken as the points of observation, these inequalities disappear.

* *Comptes Rendus*, II, 576.

† *Comptes Rendus*, LXII, 708; LXIII, 196.

PAPERS FOR THE USE OF STUDENTS.

No. 1.—On the Measurement of the Angles of Crystals.

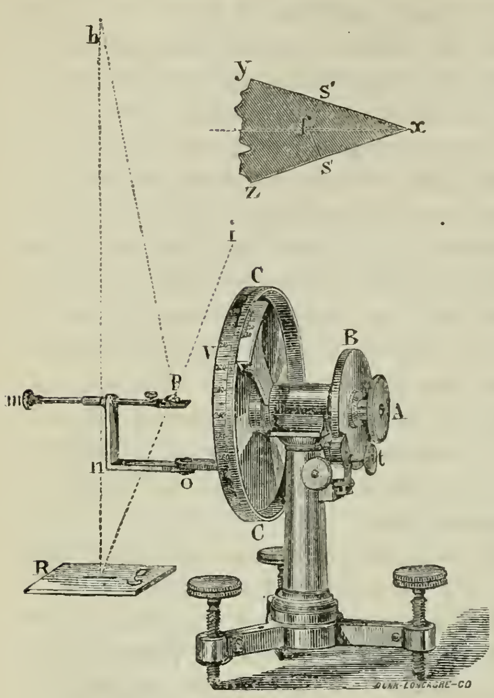
By Prof. LEEDS.

It will be necessary in this and following articles to give a minute description of the apparatus which we propose to employ, and of the proper method of using it. But our chief object is to point out the difficulties which the student will encounter, the errors to which his measurements are liable, and the way of dealing with both.

With regard to the common goniometer, however, but little need be said. If it is graduated to whole or half degrees, an approximation nearer than fifteen minutes to the true angle cannot be demanded. When the faces of the crystal which include the required angle are very rough, or small, or partially imbedded, the permissable error is greater. In a properly constructed instrument, when the arms are pushed backwards and forwards, the central line of the slots constantly coincides with the axis. Moreover, the bevelled edge of the arm which is used for reading is coincident with the extension of the central line of the slot. In some common goniometers of superior workmanship, through ignorance on the part of the maker, the brass piece through which the axial screw is passed, is swelled into a disk at the end, and prevents the measurement of obtuse angles, and also of acute angles of small crystals. It must be ground away until the brass surface falls a little within the outer surfaces of the arms.

Wollaston's Reflective Goniometer.—In case the faces of a crystal are bright enough to reflect an image distinctly, the angles included between them may be measured by a greatly superior instrument, the reflective goniometer of Wollaston. Even with very small crystals, the determinations should be accurate almost to the minute. It consists of a vertical circle C C, graduated to half degrees. The vernier V, with its scale of 30 divisions, permits the reading of the half degrees to be carried to minutes. The wheel B should be secured immovably to the axle of the circle C C, and should communicate its motion backward and forward, without loss or change to the graduated circle, to the parts *o n m*, and to the crystal to be

measured. A final adjustment is made by means of the tangent screw, t. The wheel A communicates directly with $m\ n\ o$ by means of a rod which passes through the hollow axle of B and C, and rotates the crystal without disturbing the graduated circle. The crystal is attached by wax to the plate p, which can be moved from side to side, or secured by a screw that passes through one side of a slit made in the end of the sliding rod m. By means of the parts $o\ n\ m\ p$, the crystal may be placed in any required position. In the first place, by altering the position of p in the slit, or by revolving it around the end of the screw as a centre point; by rotating m upon itself, or sliding it in and out; by revolving $n\ o$ around the hinge o.



The adjustment of a crystal $y\ x\ z$, consists in making the edge x between the faces whose angle is to be determined parallel with the axis of the graduated circle, and in making this axis fall somewhere in the plane $f\ x$, which bisects the required angle. The measurement of the angle of a crystal consists in finding precisely the direction of any normal, as F S, drawn to one of the faces, and in noting through how many degrees and minutes the corresponding normal $f\ s$, drawn to the other face, must be revolved in order that it should take up the same position as that formerly occupied by $f\ s$. Such an adjustment is best effected in the following manner and order: The part $n\ o$ is made perpendicular to the graduated circle.

The sliding rod m is pushed in or out until a line drawn through o parallel to the circle C passes through the middle of the plate p. The plate is then detached and the crystal adjusted by the eye, so as to fulfil as nearly as possible the conditions mentioned above.

This is a troublesome operation, but by using great care in its performance much subsequent trouble and loss of time are avoided If the crystal is very small, the edge x may be made to coincide with the axis. The plate is now restored, and its longer sides made parallel with the axis. It is then rotated by means of the sliding rod until the image of the top or cross-bar of a window sash, at a distance of from 6 to 12 feet, seen by reflection from the face $y\,x$ of the crystal, is made to coincide with the image G of the same object seen by reflection in the mirror R. In order that this may be done conveniently, the instrument should be elevated until, when both elbows rest upon the table, one hand may easily manipulate A or B, and the other m or p. The mirror R is placed upon the table in such a position as to allow the image of h to be seen with ease. Since the image reflected in the mirror must of necessity be parallel with the cross-bar itself, it is evident that it is better to employ a mirror than to rule a line upon the table, or upon the floor in front of the window, as is sometimes done.

If the two images nearly coincide, the crystal should be rotated by m, and the same operation repeated with the face $z\,x$. If the coincidence is far from perfect, the position of the crystal on the plate is to be altered before proceeding further. When approximate coincidence has been obtained with $z\,x$, the crystal should be rotated backwards, to see that in this operation the approximate coincidence, so far as the first face is concerned, has not been destroyed. When this part of the work is carefully and thoughtfully performed, the final adjustment may be easily effected. This consists in rotating the crystal by the wheel A, and in perfecting the coincidence of the images, as seen in both faces by slight movements to and fro of the part $o\,n$ and the plate p.

The measurement of the angle is a much easier operation than the adjustment. It is effected by bringing one eye as near as possible to the crystal (it is better to keep both eyes open), and maintaining it in precisely the same position. The discrepancy between successive measurements of the same angle is largely due to slight inadvertent changes in the position of the eye of the observer. Down to a certain limit, the error from this cause is less, as the faces including the angle to be measured are smaller. The position of $n\,o$ should be so adjusted in the beginning, that when the crystal is rotated it should not come into the way, and bring about a change in the place of the observer's eye. The wheel A is then rotated until

coincidence of the images is obtained in one of the faces. If there is any difficulty in procuring such a coincidence by the motion of A alone, the wheel B should be clamped, and the tangent brought into use. The number of degrees and minutes is now to be noted by examination of the graduated circle and vernier, with the aid of a magnifying glass. The crystal is then rotated by B, care being taken to impart no motion to A during the operation, until exact coincidence is established in reference to the second face. The difference of the readings subtracted from 180° gives the angle required. This is true of such an instrument as is figured above, the circle of which is graduated to 360°, and can be rotated in two directions. In some instruments, however, the circle is graduated from 0° up to 180°, and this 180° again is made the zero point of another graduation into 180 divisions, ending with the point of beginning. And furthermore, the circle is provided with a stop, which arrests the motion when the point marked 180° coincides with the zero of the vernier, and makes it necessary to rotate the circle from 180° towards the zero point of the circle. Consequently, the reading obtained, when the position of the second face of the angle of a crystal is properly adjusted, is the angle required.

In using Wollaston's goniometer, the following precautions should be taken: 1st. The axis of the instrument should be horizontal. 2d. The plane of the graduated circle should be perpendicular to both lines. Both these points can be determined with sufficient nicety by inspection. 3d. The graduated circle should be centred with the greatest accuracy. This should be tested by performing the measurement of the same angle with every successive portion of the circle. A hexagonal crystal, such as quartz, will be found convenient in such a determination. If the circle is not accurately centred, the angles found will be too large on the side of the circle where the radii are smaller than the half diameter, and too small when they are greater. 4th. The motion of A and B should be altogether independent. 5th. The clamping and unclamping of the tangent-screw should make no difference of position of the circle. 6th. The wheel B and the circle C should be maintained at a constant tension (in Soleil's instruments this is effected by a circular spring washer of brass, placed between B and the central part surrounding the axle), so as to remain stationary while B is rotated, while at the same time there should be no "wabbling" of B upon the axle of C. For the sake of illustration, I append this series of

measurements of one and the same angle, taken before this source of error was suspected:

360° 38′	300° 19′	240° 43′	180° 53′	121° 8′	60° 49′
300° 52′	240° 35′	180° 52′	120° 52′	60° 51′	56′
59° 46′	59° 44′	59° 51′	60° 1′	60° 17	59 53′

The true angle was 60°.

This source of error may be exposed at once by tightly clamping the tangent-screw, and observing, by means of the vernier, whether there is any change of place of the graduated circle when strongly twisted to the right or left. If it moves, the wheel B is forced up upon the axle until it is perfectly secure, the circular spring washer being made thinner if necessary.

I give below some determinations of the angles of a small crystal of quartz from Lake George, in order to illustrate the method of working by an easy example. In four measurements, we obtain for the supplement of the angle included between two faces of the prism, 59° 59½′. This may be seen by taking the mean of the following results:

360° 9′	300° 5′	240° 5′	180° 6′
300° 5′	240° 5′	180° 6′	120° 10′
60° 4′	60°	59° 59′	59° 56′

In this particular crystal, it happens that the face 2–2 is so small that it is only by the beam of light which it reflects into the eye when rotated to the proper position, that the attention is attracted to its existence; yet this beam is sufficiently distinct to subserve our purposes in measurement. Since the face of the rhombohedron immediately adjoining 2–2 is likewise very small, we may measure all the angles lying in one zone at the same time. This is done by seeing that the two images can be made to coincide when the four including faces are brought successively into view. The results thus obtained are as follows:

For $i \wedge 22$,

246° 22′	133° 26′
208° 22′	95° 11′
38° 10′	38° 13′

Supplement of mean,		147° 48½′.	
For 22 $\wedge$ R,	208° 22′		95° 11′
	179° 18′		66° 10′
	29° 4′		29° 1′
Supplement of mean,		150° 57½′.	
For R $\wedge$ — 1,	150° 57½′		
	292° 32′		179° 15′
	246° 13′		133° 3′
	46° 19′		46° 12′
Supplement of mean,		133° 44½′.	

NOTE.—It may appear strange to the student that the angle formed by the ray reflected from the face of the crystal, should be assumed equal to that reflected from the mirror. It is evidently greater when both surfaces are horizontal, and consequently parallel. In fact, to effect coincidence of the two reflected rays, the crystal must be rotated until the face under observation dips slighty downwards in the direction of the window. But the second face of an angle must be made to dip by precisely the same amount, and the difference of the two readings gives exactly the angle required.

THE MAGIC LANTERN AS A MEANS OF DEMONSTRATION.

BY PROF. HENRY MORTON, PH.D., President of Stevens Institute of Technology.

Continued from Vol. LV. page 420.

DURING the time which has elapsed since the publication of the last paper in the series on the above subject, which appeared in this *Journal* in the 53d, 54th and 55th volumes, many new points of experience and observation have come within my field of view, which are of value in connection with the same subject, and with which I propose to supplement my former papers.

In the first place, with reference to the preparation of oxygen, many methods for which are noticed in the article Vol. LIII. page 55 of this *Journal.*

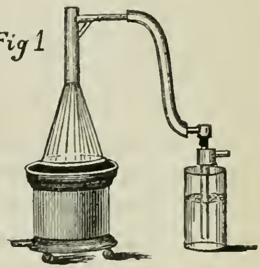
Preparation of Oxygen.—An experience of several years has led me to the exclusive use of the apparatus to be now described as preferable to any of the others before mentioned.

A conical vessel is obtained, which any tinman can make of thin

sheet-iron, such as is used for stovepipes. It is 11 inches high, $6\frac{1}{2}$ inches in diameter at the bottom, and $1\frac{1}{4}$ inches at the neck. The joints are "upset" and hammered close, which makes them nearly air-tight. A piece of light brass tubing, large enough to fit over the conical neck, is then closed at one end and provided with a lateral branch of, say, $\frac{1}{4}$ inch diameter and 5 inches length.

The charge of, say, one pound chlorate of potash with 4 to 6 ounces of black oxide of manganese is put into the iron vessel, and the top luted on with a little plaster of Paris, and the first time the vessel is used some very thin plaster is run into the seams. A wash bottle is then connected with the outlet tube by rubber hose, and the gas bag with the wash bottle. Fig. 1 shows the whole apparatus, including the gas stove, ready for use.

Fig 1



A good heat is applied to the bottom of the iron vessel, and continued until the gas comes through the water in the bottle with considerable rapidity, when the heat may be diminished, but should be renewed at once if the flow of gas decreases.

The theory of a safe and successful working of this process is this: If the mixture is very rapidly heated, one part of it will be entirely decomposed without fusing before another part has reached the required temperature, and so the evolution of gas will be gradual and steady. But if the heat is more gradually applied, the entire mass may be slowly fused with very slight escape of gas, but when once the temperature for this is reached the action goes on simultaneously throughout the mass, and is of a very violent character. There is then, also, a liability for the melted material to froth up and close the outlet. The only risk in connection with such an accident, if these sheet-iron vessels are used, is that of making a dirt, for the flat bottom of the retort yields to a very moderate pressure, and opens at the edge with a puff, which can hardly be called an explosion.

By applying the heat rapidly, as with a good gas-stove or coal-fire, all difficulty can, however, be entirely avoided. The heating cannot be too rapid, the only trouble is from a want of heat at first. I have blown the bottoms out of several retorts in experimenting

on this subject, and now feel perfectly secure of a satisfactory result where a sufficiently strong heat is at command.

The wash bottle should never be omitted; it indicates the progress of the reaction and prevents such accidents, from distillation of the rubber tubing or bag, as are described in this *Journal*, Vol. LV., pages 4 and 81,—and which are sometimes of a very serious character.

After using, the retort above described should be cleaned out by breaking up the residuum with a sharp stick, and not by washing. The retorts will then last for a very long time, indeed, far outlasting those made of copper.

Gas Bags.—The oxygen gas bag should be distinguished from that used for illuminating gas by a marked difference in its stopcock. A mark on the bag is well also, but likely to be useless when most needed, namely, in the dark, as when in use. By using hydrant cocks for the one gas, and gas cocks for the other, all chance of mistake, even in the dark, can be obviated.

Condensers.—The attempt has frequently been made to employ very large condensers for small pictures by setting the latter forward in the cone of rays coming from the former until the picture was just covered by the contracting field of illumination, and thus getting all the transmitted light upon the picture. The object glass used in such a case would of course be of a shorter focus than that employed with a large picture set close to the condenser, or if not, would be moved proportionally forward.

Such an arrangement is, however, in all cases more or less unsatisfactory, giving a field of light on the screen, which is apt to be defaced by a blue-grey ring near the centre and with a red edge, and though by special adjustment and the covering of the margin with a diaphragm, a tolerable result may be obtained, this is never equal to that which the same light will yield with condensers well proportioned to the pictures to be used. As the cause of this has not to my knowledge been anywhere discussed, and leads moreover to some very important general principles bearing on the structure of condensers, I think that a brief explanation will not be amiss in this place.

If a system of condensers are well arranged, the front surface of the outside lens will be evenly illuminated, as may be seen by placing a sheet of thin paper against it, but from this surface the rays will travel outwards with all the irregularities of distribution

caused by spherical and chromatic aberration, and by the action of the condensers as image-producer of the source of light.

If now the object-glass, while in focus with the object, is also in focus with the front of the condenser, it will produce on the screen an image of the equally illuminated surface of the condenser, the irregularities in direction of the rays as they leave that surface having, as we know from the simple theory of image formation by lenses, no effect inimical to such a result. But if the object is moved forward on the cone of rays issuing from the condenser, then, when the object glass is in focus with this, it will tend to produce an image of a section of the light-cone made in this same plane. Here, however, the irregularities in distribution of the light before noticed have developed to the extent of rendering the area of such a cross section very irregular in illumination and color, and this irregularly illuminated surface the object glass will reproduce in the image which it throws upon the screen [illegible]

[illegible] ect leads
[illegible] ndenser,
[illegible] surface

SOME REMARKS ON [illegible] A NEW FORCE, BY WILLIAM CROOKES, F. R. S."

By Coleman Sellers.

In the paper under the above quoted caption, which was given to the world in the July number for this year of the London *Quarterly Journal of Science*, there is a foot note, p. 341, as follows: "It argues ill for the boasted freedom of opinion among scientific men, that they have so long refused to institute a scientific investigation into the existence and nature of facts asserted by so many competent and credible witnesses, and which they are freely invited to examine when and where they please." The experiments which Mr. Crookes describes in the paper, and which he is not afraid to give to the world as convincing proof of the existence of a force, to which he has ventured "to give the name of Psychic," are in all respects similar to those shown in this country by so-called "medi-

on this subject, and now feel perfectly secure of a satisfactory result where a sufficiently strong heat is at command.

The wash bottle should never be omitted; it indicates the progress of the reaction and prevents such accidents, from distillation of the rubber tubing or bag, as are described in this *Journal*, Vol. LV., pages 4 and 81,—and which are sometimes of a very serious character.

After using, the retort above described should be cleaned out by breaking up the residuum with a sharp stick, and not by washing. The retorts will then last for a very long time, indeed, far outlasting those made of copper.

Gas Bags.—The oxygen gas bag should be distinguished from that used for illuminating gas by a marked difference in its stopcock. A mark on the bag is well also, but likely to be useless when most needed, namely, in the dark, as when in use. By using hydrant cocks for the one gas, and gas cocks for the other, all chance of mistake

Cond
very la
ward ir
was jus
getting
used ir
employ
would

ERRATUM.

In title, for *Investigations* read *Investigation.*

Such an arrangement is, however, in all cases more or less unsatisfactory, giving a field of light on the screen, which is apt to be defaced by a blue-grey ring near the centre and with a red edge, and though by special adjustment and the covering of the margin with a diaphragm, a tolerable result may be obtained, this is never equal to that which the same light will yield with condensers well proportioned to the pictures to be used. As the cause of this has not to my knowledge been anywhere discussed, and leads moreover to some very important general principles bearing on the structure of condensers, I think that a brief explanation will not be amiss in this place.

If a system of condensers are well arranged, the front surface of the outside lens will be evenly illuminated, as may be seen by placing a sheet of thin paper against it, but from this surface the rays will travel outwards with all the irregularities of distribution

caused by spherical and chromatic aberration, and by the action of the condensers as image-producer of the source of light.

If now the object-glass, while in focus with the object, is also in focus with the front of the condenser, it will produce on the screen an image of the equally illuminated surface of the condenser, the irregularities in direction of the rays as they leave that surface having, as we know from the simple theory of image formation by lenses, no effect inimical to such a result. But if the object is moved forward on the cone of rays issuing from the condenser, then, when the object glass is in focus with this, it will tend to produce an image of a section of the light-cone made in this same plane. Here, however, the irregularities in distribution of the light before noticed have developed to the extent of rendering the area of such a cross section very irregular in illumination and color, and this irregularly illuminated surface the object glass will reproduce in the image which it throws upon the screen.

One general conclusion to which this view of the subject leads us is, that in arranging a set of lenses to form a lantern condenser, we must have in view the equal illumination of the outer surface as one of the vital elements.

(To be Continued.)

SOME REMARKS ON "EXPERIMENTAL INVESTIGATIONS OF A NEW FORCE, BY WILLIAM CROOKES, F. R. S."

By Coleman Sellers.

In the paper under the above quoted caption, which was given to the world in the July number for this year of the London *Quarterly Journal of Science*, there is a foot note, p. 341, as follows: "It argues ill for the boasted freedom of opinion among scientific men, that they have so long refused to institute a scientific investigation into the existence and nature of facts asserted by so many competent and credible witnesses, and which they are freely invited to examine when and where they please." The experiments which Mr. Crookes describes in the paper, and which he is not afraid to give to the world as convincing proof of the existence of a force, to which he has ventured "to give the name of Psychic," are in all respects similar to those shown in this country by so-called "medi-

ums," and which have been cited as convincing proof of the presence of "spirits," to act through certain persons upon inanimate matter. So far from scientific men being unwilling to examine into these "facts," I have never met any but who were rather anxious to have an opportunity to make such tests as they deem proper to avoid the possibility of trickery. Time and again has deception in these practices of "mediums" been discovered, and time and again have they been exposed; yet, with what result? "Believers are believers still," as Prof. Tyndall in his Fragment of Science, says, when speaking of his attempts at an investigation. "It is in vain that impostors are exposed and the special demon cast out. He has but slightly to change his shape, return to his house, and find it empty, swept and garnished."

In regard to the "timidity or apathy shown by scientific men in reference to this subject," it may be said, scientific men are men who make the natural sciences a study, and some are more competent to investigate certain subjects than others are. Those best fitted, from education and practice, to consider any one scientific subject, are usually termed experts in that particular art or science. Now, the question at once arises as to what class of experts such phenomena as those described by Mr. Crookes should be referred. Among numerous scientific men of note with whom it has been my good fortune to be intimate, I have found none who were experts at legerdemain. They had turned their attention to matters of more account, and yet were always interested when looking at skillfully conducted deceptions. Experts in sleight-of-hand prefer showing their skill to educated people, as they can the more readily appreciate the perfection of the deception, and yet are no more likely to detect the artifice than others. Among mechanics can be found many who have turned their attention, by way of pastime, to these mechanical puzzles, and to them it affords a healthy mental exercise, to devise ingenious combinations, and to work them out with the supple fingers of the skilled workman. A mechanic, reading of the experiments as described by Mr. Crookes, does not see in them any proof of the existence of any new force, but sees only the possibility of deception by very simple means. But mechanics are not usually classed among scientific men; and perhaps their testimony would be ruled out of the grand court of inquiry.

On page 341, again, we have given a mahogany board, "36 inches long by 9½ inches wide, and 1 inch thick," with "at each end a strip

of mahogany, 1½ inches wide, screwed on, forming feet." This board was so placed as to rest with one end on the table, the other suspended by a spring balance, and, so suspended, it recorded a weight of 3 pounds; *i. e.*: a *mahogany* board of the above dimensions is shown to weigh 6 pounds—3 pounds on the balance and 3 pounds on the table. A mechanic used to handling wood wonders how this may be. He looks through his limited library, and finds that scientific men tell him that such a board should weigh about 13½ pounds. Did Mr. Crookes make this board himself? or did Mr. Home (whom the papers here call "the great American Spiritualist") furnish it as one of his pieces of apparatus? A similar machine has been used in this country, and for the same purpose. It would have been more satisfactory if Mr. Crookes had stated, in regard to this board, who made it, or who made the spring balance; for may be, it was in fault, and if so, with a starting point at least 3 pounds wrong, how can we depend upon the expression of 6 pounds psychic force, as developed by the oscillation of the board? The experiments described are only two in number. An accordion, held upside down in the hands of the "medium," seemed to emit sounds, and when the "medium's" hand was removed, floated in the air. The board and spring balance, described as above, formed the second experiment. When Hermann astonishes the world by his floating wand, he does it as fairly as Mr. Home, but does not claim for it other than an example of his skill at prestidigitation. Scientific men tell us that no deceptions are more easy than those involving position of sound, or rather the determination of the source of sound. An accordion has always been a favorite instrument in the hands of "mediums," not so much on account of its portability as on account of similar sounds being readily produced by devices very readily concealed, if not by the mouth of the operator. A careful examination of Mr. Crookes' paper gives the impression that all the apparatus used was prepared without the knowledge of Mr. Home, and that any collusion was impossible; but still, there is wanting a degree of emphasis which should have specified these conditions.

"Before Mr. Home entered the room the apparatus had been arranged in position, and he had not even had the object of some of it explained before sitting down." Mr. Crookes should have stated which part of the apparatus he alluded to when he said "some of it," &c. Let it be discovered that the 6 pound mahogany board was furnished by Mr. Home, and the experiments will not be so

convincing, for nothing would be easier than the arrangement of machinery which should enable the operator to do what Home did, and would defy detection short of chopping up the board or destroying the spring balance. For my part, I feel sure that the same thing can be done by purely mechanical means with any board and any spring balance, provided those who see the experiment are not told before hand that the experiment is a mere feat of sleight-of-hand. Practitioners of "magic" will thank Mr. Crookes for putting their art among the sciences and for furnishing them with a new term. We shall now hear from the juggler's stage a scientific lecture, fully illustrated, to prove the possibilities of the new "psychic" force.

Mr. Crookes tells us, with great exactness, where the accordion used in "these experiments" was purchased, and, further, that it had not been seen or handled by Mr. Home previous "to these experiments." He further alludes to other experiments having been tried at his own house prior to those on the evening which he writes about—some with positive and some with negative results: he leaves us, however, in the dark as to whether "these experiments" alludes to all, at different times, or those of this particular evening. If the purchase of the accordion was so important a matter, surely the experiment with the board and balance, which he considers more conclusive, would warrant the same exactness as regards the origin of the board, provided it had not been purchased by Mr. Home as a piece of apparatus adapted to his requirements.*

Bibliographical Notices.

The Roadmaster's Assistant and Section Master's Guide, a manual of reference for all having to do with the permanent way of American Railroads. By William S. Huntington. Chicago: A. N. Kellog, 1871.

The active and extensive construction of new railroads, and the crowded trains upon those in actual use, make a well digested and sound practical work upon the subject of laying and repairing the

* It may be well to state that the author of this critique is quite as accomplished in the field of legerdemain as in that of mechanics. This fact, which is known however only to a privileged circle of friends, to whom the occasional exhibition of his proficiency in the art will be recalled in this connection with great interest, lends to his review a peculiar value.—Ed.

track, valuable not only to practical men, having charge of construction and repairs, but of those who bear the expense. This little octo decimo volume, of scarce one hundred pages, gives, as the writer claims, the results of twenty-five years experience in track laying and track repairs, in various circumstances of good and bad roads and management. The volume is, he says, a practical book for practical men, and it bears internal evidence that the writer is one of that class. The subjects treated comprise, apparently, the various larger and lesser details of materials and management necessary to make and maintain a good and safe track, with a copious table of contents and a copious index. We have no hesitation in commending this little work, not only to all practical track layers, but to all who are both directly and indirectly in authority over them. We rejoice, as well in our editorial capacity as in that of railroad passenger, that our author concludes by a chapter upon the subject of *accidents*, and the means of avoiding them, among which the proper construction and maintenance of track is of very great importance. May the warnings herein contained sink deep into the hearts of railway directors, and may the motto with which the author finishes his work become also theirs: "*Eternal vigilance is the price of safety.*" As to the Tyler Safety Switch, which our author recommends, we have naught to say against it, but we would encourage the managers of railroads not to omit examination of the Wharton Switch; in fact, to spare no pains to secure the best switch, by whomsoever made or sold.

Tables for Calculating Excavation and Embankment. By E. C. Rice, C. E. R. P. Studley & Co., St. Louis, 1870.

This is a well printed folio of some fifty pages. It begins with four pages of theoretical and practical introduction, which omits all notice of previous works upon the same subject. This part of the work contains nothing which, in our opinion, is deserving of notice on account of its novelty; but this may sometimes be said of books which have practical advantages over their predecessors. The following description may aid our readers in judging how far this is the case in the present instance. The first set of tables, fifteen in number, occupying 18 pages, apply to prismoids 100 feet long, of level-topped cross section. These tables are adapted to nine differ-

ent widths of base or roadbed for side slopes of $1\frac{1}{2}$ to 1, to three widths of side slopes of 1 to 1. The side slope of $\frac{1}{4}$ to 1, often useful for rock cuttings, is omitted. The tables apply without interpolation, for which means are provided, to mean heights proceeding by whole tenths from 0 to 40 feet. Within the specified limits of form and dimensions, these tables give the cubic yards very conveniently; but they are not directly applicable to cases of ground sloping transversely. In this respect, they seem to us liable to some of the objections made by Mr. Morris to the tables of Macneil, in this *Journal*, Vol. XXV, 1840. These objections our author seeks to obviate in a following set of fifteen tables co-extensive with the first set. By the use of these last, the heights of equivalent level end cross sections are found, when the ground slopes transversely, and the first set of tables is then used with these heights, in accordance with the so-called method of Equivalent Level Heights. To find these heights, Mr. Rice makes use of the areas of the end cross sections, but gives no satisfactory rules or tables for obtaining these areas, although his tables close with three pages of areas of triangles, which seem intended to assist in this operation. Here, we think, his work is at least deficient in respect of rules and examples. With regard to his first set of tables, the reader who will compare his Table No. 6 with Mr. Warner's Table XIV, which is applicable to ground sloping transversely, will, we think, perceive an essential identity between Table No. 6 and the 0 degree column of Table XIV.* On the whole, it seems to us that although Mr. Rice's work presents a great extension of tables in some directions, this is accompanied by an equally notable restriction in other not less important directions. No sufficient provision is made for the computation of work partly in excavation and partly in embankment, and the book does not seem intended to embrace the important subject of preliminary estimates. We do not consider that it presents either a complete theoretical or practical system.—J. W.

* New Theorems, Tables and Diagrams for the Computation of Earthwork, first published in 1861, now sold by H. C. Baird, Philadelphia.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

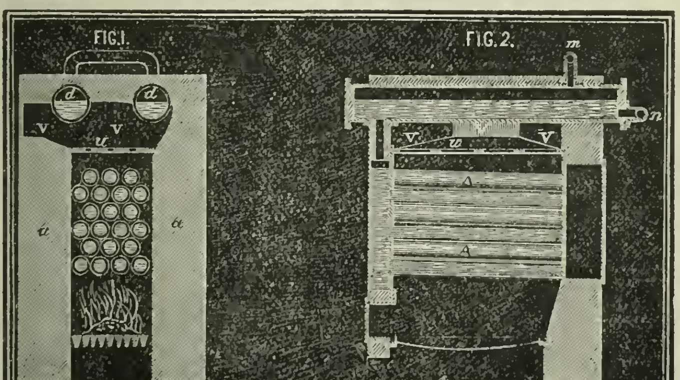
PROMOTION OF THE MECHANIC ARTS.

Vol. LXII.] OCTOBER, 1871. No. 4

Editorial.

ITEMS AND NOVELTIES.

Ernst Alban's Boiler.—Half a century ago Alban was occupied with the attempt to contrive a tubular boiler for high-pressure steam-engines. He was successful. We give below illustrations and description of it:



"Fig. 2 is a longitudinal section of a boiler and furnace on this principle, the dimensions being given for a boiler of 10-horse power. A A are the generating tubes, having their back ends shut by screwed covers, and their front ends connected by bolts to the back plate of the case B. Each tube is inclined, and has an upper and lower oval communication with the case, as shown.

"I lay the tubes in eight rows or tiers, one over another, and in such wise that the tubes of each row stand over the interstices between those of the row immediately below.

"Fig. 1 is a transverse section through the side-walls *a a* and all the tubes. The lowest row of tubes has the greater number. Space between tubes $1\frac{1}{2}$ inch, and between tube and wall $\frac{3}{4}$ inch. The case is from 6 to 8 inches deep, 40 to 42 inches high, and 8 to 12 inches wider than the wider rows of tubes, its sides made of cast iron, and front of $\frac{1}{2}$ inch and back of $\frac{3}{4}$ inch wrought plate, tied by strong bolts to prevent bulging.

"Internal construction is peculiar, to favor circulation of the water and escape of steam. Top end is connected by pipes *g* to the separators and receivers *c* and *d*. These are made of $\frac{1}{4}$ or $\frac{3}{8}$ inch wrought plate iron, provided with strong cast iron end covers, and are not over 18 inches diameter, are connected at back and top by *n* and *m*, water and steam pipes, of equal size—one square inch area to every 25 square feet of heating surface of the tubes.

"The heated gases are detained by the perforated baffle-plate *u*, and afterwards escape, from under *c* and *d*, through the vent *v*.

"A large boiler of this description, which I have already constructed for an engine of 30-horse-power, has two cases, each with 28 boiling-tubes, lying in eight rows one above another; and I have used two separators, with a single receiver between them. This boiler has not only fulfilled, but far exceeded my expectations: the heat is so perfectly applied, the steam production so regular, the water-level so quiet, and the whole so safe, trustworthy and convenient, that its advantages in these respects can seldom be equalled in the most perfect boilers of the ordinary construction." J. H. C.

The Manufacture of Platinum.—As an item worthy of record amongst our mechanical news, we would notice the establishment in our country of a new manufacturing industry, namely, that of the manufacture from the raw material of platinum vessels, wire, etc., for the use of the chemist, and of those engaged in technical pursuits.

For our supply of these materials we have been, until the establishment of this enterprise, entirely dependent upon European makers. The establishment is now, we believe, successfully conducted, in New York, by Mr. H. M. Raynor, and we wish the undertaker of it success.

Steam-Boiler Explosions.—Mr. J. B. Stevens, of the Camden and Amboy Railroad Company, as we learn from the New York *Evening Post*, has commenced a series of experiments on a large scale, that may be expected to throw some light upon the very important subject of steam-boiler explosions.

He has selected four old boilers, recently removed from steamboats, and of ages ranging from 13 up to 25 years, and proposes a series of experiments, commencing with their rupture by hydraulic pressure, and finally exploding them by steam.

He has invited a number of experts and scientific men to witness them, and we are promised a detailed account when they shall have been concluded.

The first meeting took place Sept. 2d, in presence of Mr. C. W. Copeland, and several other experts and builders of New York, and Professor Thurston, of the *Stevens' Institute of Technology.*

The most prominent fact noticed in this first experiment on four boilers was that the stayed surfaces—which are the strongest portions of new boilers, usually—were, in all of these old boilers, the weakest. This is a very valuable piece of engineering information. The boilers will be repaired, and the experiments then resumed.

Floors for Workshops.—Ground floors for large machine-shops are very often made with the plank resting on the surface of the ground, the sleepers to which they are spiked being imbedded in the ground. I have been informed that white pine planks last longer than oak for the same purpose, and it is in fact considered the best wood for the purpose. Some attempts have been made to prevent the decay of such floors, but the question has at once arisen as to the economy in each case. Floors where heavy machinery is erected are subject to very severe wear, and it is asserted that a two-inch white pine floor will wear through in such a place before it has rotted out. On the line of the Georgia Central Railroad floors have been laid in a peculiar manner, which is deserving of note. The ground is levelled off for the floor, and ditches dug to receive the string-pieces or joists; these are coated with melted rosin, before being laid, on the three

sides in contact with the ground. The floor is then laid, with a space of half an inch between the surface of the ground and the under side of the floor planks. After the floor is all down, holes are bored, at intervals of say three feet, over the whole surface, and melted rosin poured into the space below the floor, to entirely separate the planks from the ground. Mr. Wm. M. Wadley, the President of that road, says that floors so laid show no signs of decay, after many years use, in places where the floors usually rotted out in a short time. The Asphalt pavement was adopted in one large shop in this city, but I have not heard how it has stood the test of wear. It was made of spawls from granite mixed with coal tar and asphalt.

In the establishment of Messrs. Wm. Sellers & Co., of this city, the floor upon which the tools rest is made of iron, secured to foundation walls of bricks, while the part of the floor upon which the workmen stand is made of pine plank, readily renewed if it rots out. The asphalt pavement seems to be admirably adapted to the flooring of stables, and in one instance I have seen plank laid upon a floor of asphalt, in the stalls of a modern stable, the proprietor deeming the asphalt composition too hard for the horses' feet. In connection with the decay of floors it may be well to note that reliable builders state that on outside walls the ground floor joists are likely to rot off in about fourteen to fifteen years. My attention was called to this by the sinking of the floors in two houses in West Philadelphia, which had been built about fifteen years. An examination of the case showed that all the joists which had so rotted had been built into the wall at the ends, and the rot had occurred where the timber was excluded from the air and submitted to the moisture of the outside walls. Examining houses in the country which have been erected for at least fifty years, I find the joists still sound, but in no instance have I observed the practice followed of carrying up the cellar wall flush between the joists, as is now the custom in cities. It seems evident that the best plan is to make an offset in the cellar wall to receive the joists, and, if the space between the joists is to be filled up for the looks, to let the filling in fall back of the face of the wall, below the joists, say one or two inches. COLEMAN SELLERS.

Errata to Article on a Ship-Channel across Cape Cod.

U. S. ENGINEER'S OFFICE, *Oswego, N. Y., Aug.* 12, 1871.

* * * * * * * * *

Owing to my absence from my offiee in Boston, and a misapprehension on the part of the person left in charge of the office, I did not

receive the proof-sheets of the article on a Ship-Channel across Cape Cod, which appeared in the June and July numbers of the *Journal.* The result was that a number of typographical errors appeared in the article, which are herewith corrected :

In foot-note to page 390, vol. lxi, the last sentence should not be included in the quotation. It should read: * * * relation of these basins."—Mass. Pub. Doc. No. 41, 1863. Not to underestimate, &c.

In 3d foot-note to page 388, read "Hagen," instead of "Hagar."

On page 42, vol. lxii, 1st line, instead of "highest," read "lightest."

" " 4th line, supply after the word city, "converting the portion of the river opposite the city."

Page 42, 15th line, instead of "omitting," read "uniting."

In first note to page 45, read "Harwich," instead of "Harurch."

Jos. P. Frizell.

Detroit River Tunnel.—We learn that the work on the Detroit River Tunnel will be commenced at once, and that Mr. Cheesebrough, the already famous engineer, will take charge of the work.

The plan of the tunnel contemplates a series of three cylindrical tunnels. Two of these will be for railroad purposes, each being $18\frac{1}{2}$ feet interior diameter. They will be parallel, and 50 feet apart. This plan is deemed preferable to a single tunnel with double tracks, both on account of less liability of accident to trains and delay from obstructions, and on accouut of the strength and economy of the structure. The third tunnel will run under the river, and below and midway between the other two. It is for drainage purposes only, and will have an interior diameter of five feet. The third tunnel will be constructed first, in order to drain the other two tunnels as the work progresses. It is expected that the building of the lower tunnel will determine the feasibility of the entire project, and this will be completed before work is undertaken on the railroad tunnel.

Work will be commenced on the grounds of the Detroit and Milwaukie Railroad Company. Here a shaft, ten feet in diameter, will be sunk to the required depth, and excavating under the bed of the river will proceed from that point. As the excavating proceeds, a shell of brick masonry will be constructed in a permanent manner. By the time that the middle of the river is reached, operations of a similar character will be commenced on the other side of the river, and the work will proceed from both directions. If the first tunnel should

prove successful, the work upon the others will be immediately begun. The engineer estimates that a year and a half to two years will be required to complete the work. The entire length of the tunnel, not including approaches, will be about two miles, and its estimated cost nearly $3,000,000.

The New York Docks.—It is stated that the work upon the rebuilding of the docks of that city is in progress. The plan, if carried out in accordance with announcement, will secure to the city a wharf-line of thirty-seven miles, and a pier area of more than five million square feet. It is designed to build a river-wall of solid masonry along the North and East Rivers, from which, at regular distances, piers, none less than sixty and many one hundred feet in width, are to be built at right-angles.

Dies for Thread-cutting.—We are informed by the foreman of a large establishment in this city for making wrought-iron gas-pipe, that the dies for threading the ends of the pipe should be made with more material than is absolutely necessary on the score of strength, in order that the surplus metal may aid in conducting away the heat. He says that in cutting the maximum number of ends without sharpening the dies, with a solid die made of the least possible amount of metal consistent with strength, as compared with one made of, say, four times the amount of metal, the large die will cut four or five thousand ends, while the small one will be dull after cutting fifteen hundred. The cutting edges are the same in both cases.

C. S.

East River Bridge.—For the last five weeks operations have been steadily going on at the New York terminus of the East River Bridge, preparatory to placing the caisson and planting the masonry. The locality adjoins the Roosevelt Street Ferry, and presents a busy scene. About 100 men, including dock-builders and ship-carpenters, are constantly at work there under the supervision of the engineer in charge, and several divers and borers are constantly employed. At the northern end of the site a new pier has been built, and inclosed with the most solid plank, forming a perfect breakwater. This diverts the tremendous current, and gives a space of still water for submarine operations. The entire pier, which is 400 by 100 feet in extent, has been covered over in the most substantial manner, to afford conveniences for the heavy machinery, lumber, &c., to be used upon the structure. Where the caisson is to be sunk the bed of the

river has been dredged to the depth of thirty-seven feet. About twenty feet of mud and all sorts of refuse has been taken out, and several valuable and antique relics have been found, including arms, coins, pieces of ship furniture and a part of a human skull. A boring apparatus has penetrated to the depth of sixty-six feet below high-water mark, and at this point a layer of quicksand six feet in depth has been reached. It has been found that the rock strata eighty-three feet down is of a nearly uniform grade, and to this level the caisson is to be sunk. This will be a more difficult undertaking than the placing of the Brooklyn caisson, owing to the facts that this one is four feet larger than that was, and that the current will interpose a much greater opposition. The plan is to float the caisson down from its present mooring, at the foot of Sixth street, to its permanent location, Monday Sept. 11th. About eight weeks more of labor will then be required to complete the preparations for sinking it, and from that time the work of building the tower will be rapidly pushed forward.

Boiler Legislation.—At its last session, a law was passed by Congress, the provisions of which are now being carried out with commendable promptness, regulating certain matters in relation to steam boilers used on passenger boats and cars. One of the most important of these provisions declares that it shall be the duty of their proprietors to attach to every boiler used for this purpose, an automatic indicating gauge—approved by Government—which gauge shall be placed in such a position that it may be inspected by every passenger. The indicator is made to trace upon a rolling paper the various degrees of steam pressure existing in the boiler. The whole apparatus is enclosed in a locked case, the key of which is in possession of the government inspector, who has only to examine the record on the paper to decide positively as to whether or not the pressure allowed in each particular case, (determined by periodical inspection), has been at any time exceeded.

It is only by forcing the universal adoption of a rule as excellent as this, and which has been so often recommended, that the day of "unsolved mysteries" in the history of boiler explosions can fairly be expected to terminate.

Ammonia as a Motor.—For some months vague items have been circulated in the columns of the public press, announcing the news that the utilization of liquified ammonia as a motor had been

successfully accomplished by an inventor in New Orleans, La. It now appears that these detached accounts have some foundation in fact. A correspondent of the "Iron Age" forwards to the editors of that excellent journal, a report of a committee of engineers appointed to investigate the practicability of the plan in question. Of this committee, it is stated, General Beauregard was chairman, and the report was a favorable one.

The mechanical details are too complex to be here detailed, but the theory of the operation is essentially that of the ice-machine operated by volatile liquids; though the cold utilized in the latter case is to be obviated in the former, by a suitable arrangement of parts, the energetic absorption of the evaporating liquid by water being here applied to the production of motion in an engine. The car to which the ammoniacal engine was attached, has, we are told, already made 300 successful trips, at a cost which compares very favorably with the animal motor it replaces.

A New Method for the Observation of Time.—At the last meeting of the American Association for the Advancement of Science, Prof. Hilgard, of the U. S Coast Survey, developed a new use of the zenith telescope or equal altitude instrument, so successfully employed for the determination of latitude, by applying it to the observation of time. According to this method, a couple of stars having nearly the same declination, but differing some hours in right ascension, are observed on opposite sides of the same meridian; preferably in the prime vertical, by noting the time when they attain the same altitude.

If the two stars had precisely the same declination, it is obvious that the simple mean of the observed times would correspond to the mean of their right ascensions. The correction for the small difference in declination, as well as the local correction, are obtained by simple differential formulæ.

The practical usefulness of this method of "equal altitudes" depends upon the fact that so many stars have now been accurately determined in position, as to render the selection of pairs fulfilling the required conditions, either for the observation of latitude or time, an easy matter.

Meteorological.—Prof. Henry, of the Smithsonian Institution, in an interesting address upon the methods of observation, and the results of the meteorological observers engaged by the Institution, lately

remarked upon the popularly accepted belief, that the removal of forests, and, generally speaking, cultivation tended to diminish the amount of rain-fall. He expressed the opinion that the obversations of the Institution, which extend over a period of twenty years, have as yet failed to establish a theory of this kind, and that it must therefore be regarded as a gratuitous hypothesis unsubstantiated by fact.

New Applications of Electricity.—Our exchanges inform us of several new applications of this agent in the mechanic arts. One of them has for its object, the production of an engraving upon metal plates. Another is for the unexpected purpose of filling locomotive tanks with water, which we are informed is actually in use on the Chicago, Burlington and Quincy Railroad. We may mention in the same connection, that the same agent has been employed, and very successfully, for the filling of teeth, an application more surprising perhaps than any hitherto accomplished.

The inventor, Dr. Bonwill of this city, presented, at a late meeting of the Franklin Institute, a device for this purpose which attracted great attention. It consisted of an electro-magnet, of a horse-shoe form, furnished with an armature. Suitably attached to the magnet is the plugging tool. A discontinuous current passing through the apparatus, from a battery of several cells, gives a series of blows from the mallet with great rapidity, which, striking upon the upper end of the plugging tool before reaching the face of the magnet, drives the tool forward a fraction of an inch at every blow, the strength of which can be regulated at the will of the operator. The work of dentistry is hereby claimed to be greatly lessened, and the time of an operation considerably shortened.

New application of the Microscope.—The announcement is going the rounds of our contemporary scientific press that the different qualities of iron and steel can readily be determined with the aid of this instrument. The crystals appear beneath the microscope as double pyramids, and the height of these pyramids relatively to the dimensions of their bases is different for the different qualities of the metal; the disposition of the crystals is also stated to be an important factor. Whether this declaration, which is due to Mr. Schott, will prove of practical importance remains to be seen.

Prevention vs. Cure.—Perhaps the latest public demonstrations of the value of the well known adage is afforded by the appointment of an Examining Board, by the authorities of a neighboring city, to

weed out from the business (termed elsewhere profession) of dispensing pharmaceutists those who are found ignorant of a necessary knowledge of drugs and medicines.

Where so much depends upon the education and intelligence of a class in the community, it is surely unnecessary to argue the point, that a system of legislation under which incompetents may freely exercise dangerous liberties, is highly incomplete. It is scarcely necessary to add that the plan which is found to be so efficient and essential in more thickly populated countries than our own—the establishment of educational institutions under State supervision—would afford ample protection to him who has thoroughly prepared himself for his profession; while it would as effectually prevent one who is unfit, by reason of ignorance or incompetency, from competing with the former, and what is of infinitely greater importance, from imperilling the lives of his fellows.

Fluorescence.—In Repert. der Physik., E. Lommel has an interesting discussion of the subject of fluorescence, from which we extract the following:

"The fluorescent liquid used in the experiments is an alcoholic solution of an aniline color, Magdala red (Rose de Magdala), which fluoresces with a brilliant orange-yellow. To observe the behavior of this substance under the different rays of the spectrum, the light from a vertical slit is passed through a prism whose refracting edge is also vertical, and the rays thus dispersed thrown down on the liquid by a totally reflecting prism. Fluorescence begins between C and D, and continues without interruption in the same orange-yellow shade beyond the violet; it is strongest in the greenish-yellow beyond D and has two other less luminous maxima in the green been E and *b* and in the violet. On condensing this fluorescing spectrum, by means of a cylindrical lens, into a narrow band, and examining with a spectroscope, the spectrum, thus derived from the fluorescing one, contains red, orange, yellow and greenish-yellow. The scale of the spectroscope employed was such that the Frauenhofer lines had the positions:

B	25	F	90
C	34	G	137
D	50	H	162
E	71		

"On this scale fluorescence begins at 35, attains a maximum a little before D, and disappears at 53.

"When monochromatic yellow light, such as that derived from incandescent sodium vapor, is thrown in the solution, the spectrum of fluorescence has the same limits (35—53). The monochromatic yellow light has therefore produced not only red and orange-yellow rays of less refrangibility, but also yellow of the same and greenish-yellow of greater refrangibility.

"When the solution of Magdala red is placed in the red rays obtained by passing sunlight through suboxide of copper glass, it fluoresces in this red light with its usual orange-yellow, and its spectrum again extends from 35 to 53, while the red light extends to 48 only. This red light has therefore produced not only red rays, but also yellow and green-yellow of greater refrangibility. Stokes' law, that the refrangibility of the exciting rays is always the upper limit of refrangibility in the excited rays, is in this case untenable, and the very common opinion, that fluorescence is an action, in which refrangible rays are converted into less refrangible ones, appears erroneous.

"As all the exciting rays are absorbed by the fluorescing substance, absorption becomes an important point in investigating fluorescence. A concentrated dark red solution, which has only a superficial dirty orange-yellow fluorescence, transmits red only to 35. From 36 there is complete darkness. A weaker solution transmits red to 46, then faint absorption to 48; from 48 to 98 complete darkness, after which there is a faint violet. A very faint rose-red solution, which, however, fluoresces strongly orange, shows a faint absorption band between 53 and 60; between E and *b* a darker band, and then a subdued blue and violet almost to H. On comparing these results with the foregoing, it appears that the spectrum of fluorescence begins at the same point where absorption begins in concentrated solution, and that to every maximum of absorption there corresponds a maximum of fluorescence."

The Introduction of the Metrical System.—On the second day of its meeting, the attention of the American Association was directed, by Prof. Hilgard, of the U. S. Coast Survey, to the progress which had been made by the Survey, under instruction of Congress, to introduce the metrical system into general use in our country. Prof. H. stated that a special commission had visited Paris on this business, and had brought with it the standard of the French system, one of them being one of the original standard bases (the meter) established by the first French commission, which fixed the metrical system.

The standards secured by the commission are a meter bar of gilded brass and one of platinum. From these the commission have made fifty (50) sets, or copies, with all possible precaution, for distribution amongst the several States.

The bearings of the question were fully discussed, the objections being mainly the great inconvenience and pecuniary loss which would possibly be suffered by the large machine shops, whose standards of measurement would necessarily have to be altered by any legalized alteration of the standard.

In answer to this objection the cases of France and Holland were offered, which States had adopted the system from its obvious advantages, it being assumed that the change would be a gradual and not a sudden one.

A New Bronze.—We learn from a recent copy of the *Polytechnisches Journal*, that some investigators have succeeded in producing a new alloy which possesses peculiar advantages over others, for a number of processes in the arts. The peculiarity of the new compounds consists in the fact that it contains phosphorus as an ingredient. The authors have not divulged the details of the plan by which they succeed in introducing this substance into combination. It is used with copper, or with copper and tin, either with or without the addition of zinc. The alloy produced is said to be peculiarly adapted for the construction of certain portions of machinery, as also for gun-barrels.

It seems, from an editorial note from Dr. Dingler, that the attempt to introduce phosphorous into the composition of several common alloys had been repeatedly made, but without success. The well-marked influence which its presence, in even trifling quantity, exerts upon the physical properties of irons, would seem to be the ground upon which the repeated efforts to utilize its presumable influence on other metals, is based; and there can be very little doubt but that the subject is worthy of the most careful attention of workers in metal.

New Fire-test for Petroleum.—At the Indianapolis meeting of the American Association, Dr. Van der Weyde described a plan for determining the burning-point of petroleum oils without the use of fire, which is worthy of attention, as well from its simplicity and accuracy as from its safety.

It is well known that the amount of combustible vapor evolved by

a sample of these oils at a given temperature, depends, not upon its gravity, but upon its quality. Two oils (for example) of the same gravity need not necessarily evolve at 110° Fahr. (the accepted standard temperature for the fire-test) the same amount of vapor; since one of them might be a mixture of oils lighter and heavier, the mean specific gravity of which might bring them to the same weight as the other. The amount of vapor given off by the two samples at the same temperature would, however, be very different, since the one adulterated with the light oils would evolve considerably more than the simple heavy oil of the other sample. The author has taken advantage of this fact, and simply measures the amount of vapor given off by the oil at the standard temperature, which is compared with computed or experimentally established quantities, and from this is able to announce the quality of the oil.

A graduated glass-tube, open below, is filled with the oil, and immersed in a vessel of water of the temperature of 110° F., and the amount of vapor given off is read from the graduation. The avoidance of the danger from fire, and the small liability to error, afford strong recommendations for its use.

Determination of Combined Carbon.—We present herewith a brief abstract of a very interesting paper read before the Association by Edward R. Taylor, S.B., upon an improved method of determining the combined carbon in steel. The improvement is upon the well-known method of Eggertz, and the paper is reserved for subsequent illustration and publication in full.

The balance, most ingeniously constructed of a thread of glass, with a cup of the same material attached to a hook on its end, serves to weigh the drillings in an expeditious manner. The weighed substance is then treated in a glass tube with nitric acid, and is placed in a bath kept at the temperature of 130° C.; here the action is completed in 20 minutes, and the carbon determined by comparison of the color of the solution with a series of standard colors.

Inauguration of the Mont Cenis Tunnel.—The official inauguration of the Mont Cenis Tunnel took place on September 17th, all the arrangements having been carried out with great *eclat*. A train of twenty-two carriages, occupied by various dignitaries, including representatives of France and Italy, the directing engineers of the work, and many other officials, was run safely through the tunnel, occupying about twenty minutes in the passage.

Congratulatory telegrams were received from various governments, complimenting the directors upon the successful termination of the gigantic enterprise.

Simple Process for Nickel-Plating.*—Prof. F. Stolba communicates a plan for nickel-plating, by the action of zinc upon salts of nickel in the presence of chloride of zinc and the metal to be coated. By this process, the author informs us, he has succeeded in plating objects of wrought and cast-iron, steel, copper, brass, zinc and lead. It is only necessary that the size of the objects should permit them to be covered entirely by the plating liquid, and that their surfaces should be free from rust or grease. The following is the *modus operandi :*

A quantity of concentrated chloride of zinc solution is placed in a cleaned metallic vessel, and to this is added an equal volume of water. This is heated to boiling, aad hydrochloric acid is added, drop by drop, until the precipitate which had formed on adding water has disappeared. A small quantity of zinc powder is now added, which produces a zinc coating on the metal as far as the liquid extends. Enough of the nickel salt (the chloride or sulphate answer equally well) is now introduced to color the liquid distinctly green ; the objects to be plated are placed in it, together with some zinc clippings, and the liquid is brought to boiling.

The nickel is very soon precipitated, and in course of fifteen minutes, if the work has been properly performed, the objects will be found completely coated. The coating will vary in lustre with the character of the metallic surface ; where this is polished the plating will be likewise lustrous, and *vice versa.*

Varying the process by the addition of a salt of cobalt, instead of nickel, will afford a cobalt plating, which, the author informs us, is steel grey in color, less lustrous and more liable to tarnish than the nickel.

Occlusion of Hydrogen by Nickel.—Prof. Böttger informs us† of an investigation conducted by him with the view of verifying the announcement made some months ago by Raoult, viz., that porous nickel possessed the property, like palladium, of occluding nascent hydrogen. The verification was successful, as the following abstract of his paper will show :

* Dingler's Polytechnisches Journal, cci, 145.

† Böttger's Polytech. Notizblatt, 1871, 10.

"The statement of the first observer was to the effect that nickel, when used as a negative electrode in acidified water, for 12 hours, would be found to have absorbed 165 times its volume of this gas; and that, detached from the galvanic circuit and plunged in water, the absorbed gas would be slowly evolved in the course of a few days."

Prof. B. varied the experiment by placing the porous mass in ether, and observed that for many hours afterwards numerous gas bubbles ascended through the liquid. He also succeeded in bringing about the reduction of a salt of ferric oxide, by allowing the metal to liberate its gas in the solution.

This slow evolution of the absorbed hydrogen seems to be a peculiarity not possessed (according to the author's observation) in the well-known instance of Palladium, the behavior of the two metals in this regard being strongly contrasted. The latter metal will absorb five times as much of the gas as the nickel, and when removed from the circuit, and quickly dried, will give it out again with great rapidity, heating the metal thereby so strongly that gun-cotton loosely wrapped about it will explode.

Determination of Heating-Power of Coals or other combustibles.—At the last meeting of the Franklin Institute the Secretary mentioned, in his monthly report, the process of Thompson as being worthy of the special attention of analysts, from its accuracy and simplicity.

The apparatus is extremely simple in construction, consisting of a cylindrical vessel of copper, punctured below with numerous small holes, and to the top of which is attached a hollow tube of the same material, closed with a stop-cock; a small vessel of the same form to contain the materials, and a basal piece in which to fit it. The operation is as follows: A weighed portion of the finely powdered combustible is intimately mixed in the mortar with a certain quantity of nitrate and chlorate of potassa. This mixture is next placed in the small copper cylinder, and ignited with a fuse of known dimensions. Before the combustion takes place the outer cylinder is slid down over it, being held there by springs attached to the basal piece, and the whole contrivance is plunged into a vessel containing a known quantity of water, whose temperature has been previously carefully ascertained. The combustion soon sets in, and continues with vigor until the material has burned completely out. The experiment is an exceedingly striking one to look upon. Tongues of flame shoot from

the punctured openings beneath the liquid, and thick clouds of smoke, filling the upper portion of the jar, pour down over its sides like water. The instant the combustion has ceased the stop-cock in the tube is turned, and the water allowed to enter the air-chamber, to cool down the heated interior. The operation is now concluded by again observing the temperature of the water.

From these data it is easy to calculate the results, making due allowance for the slight loss occasioned by the impossibilitity of bringing the apparatus back to its first temperature (owing to the increased temperature of the water) and the very small losses by radiation and conduction, all of which are readily susceptible of measurement.

A Photo-lithographic Process with Caoutchouc.*—G. Wharton Simpson has communicated to a photographic cotemporary, the informatian that an investigator (Swan), had found caoutchouc to be sensitive to light in a peculiar manner. A film of caoutchouc attached to a lithographic stone and exposed to the light, gives to the stone the property of taking up greasy inks upon the lighted portions. Upon this fact, the author tells us, a lithographic process is founded, by taking a sheet and coating it with a layer of caoutchouc dissolved in benzole, exposing this beneath the negative and transferring to the stone.

Curious Adulteration of Analine Colors.† Dr. M. Reimann mentions an adulteration of an aniline brown which, from the difficulty of its detection, is certainly to be regarded as ingenious. The samples offered nothing suspicious to the eye, except the irregularity in size of its particles. By repeatedly boiling the larger pieces in alcohol until the liquid was no longer colored, it was found that they had not decreased in size nor altered their shape, from which a simple test showed that they were composed of triturated wood or brown-coal; but so strongly saturated with a solution of the coloring matter that there was nothing in their appearance to distinguish them from the genuine material.

Porous Iron as a Purifier.‡—Attention has recently been directed to the energetic action which spongy iron exerts upon organic matters impurifying waters. It is asserted that impure water may be made potable with remarkable rapidity, by the use of a filterer properly constructed of this material.

* Berliner Photograph. Mittheilungen, 1871, 307.
† Dingler's Polytech. Jour., cxcix, 514.
‡ Archiv der Pharmacie, cxcv, 273.

Civil and Mechanical Engineering.

THE "WESTFIELD" STEAM BOILER EXPLOSION.

PROFESSOR R. H. THURSTON'S INVESTIGATION AND REPORT.

The steam ferry-boat "Westfield," is one of three boats which have formed one of the regular lines between New York and Staten Island.

The "Westfield" made her noon trip up from the Island to the city on Sunday, July 30th, and while lying in the New York slip her boiler exploded, causing the death of about one hundred persons and the wounding of as many more.

When the case came before the coroner, Mr. P. H. Keenan, for action, he applied to Professor R. H. Thurston of the *Stevens' Institute of Technology*, requesting him to make an examination of the exploded boiler and of its effects, and to witness the testing, by a Board of Experts appointed by the Government, of the steam gauge and safety valves, and of the iron of which the Westfield's boiler was composed. He further requested Prof. T. to assist him in the examination of experts upon the witness stand.

We give the more generally interesting portions of the report and the accompanying sketches.

STEVENS' INSTITUTE OF TECHNOLOGY,
Hoboken, N. J., Aug. 11th, 1871.

Sir:—As requested by you, I have made a careful examination of the exploded boiler of the steam ferry-boat "Westfield," as it now lies at the foot of 12th street, East River. I have examined the piece of iron carried to Police Headquarters.

I have also witnessed, with the Board of Experts appointed by Supervising Inspector, Addison Low, the testing of the steam gauge of the "Westfield," and of both her ordinary and the so-called, "Government" or "Lock-up" safety valves.

I have, in company with the same Board of Experts, witnessed the testing of pieces of iron taken from the ruptured sheets of the boiler.

Having thus fully complied with my instructions, I would offer the following report:

In view of the fact that you have requested me to assist you in the examination of experts on the witness stand, I have deemed it proper to furnish a simple statement of observed facts and of logical inferences from those facts, together with such well known scientific and

professional information, and such simple calculations as may throw light upon the subject.

I would avoid the expression of merely individual or of disputed opinions.

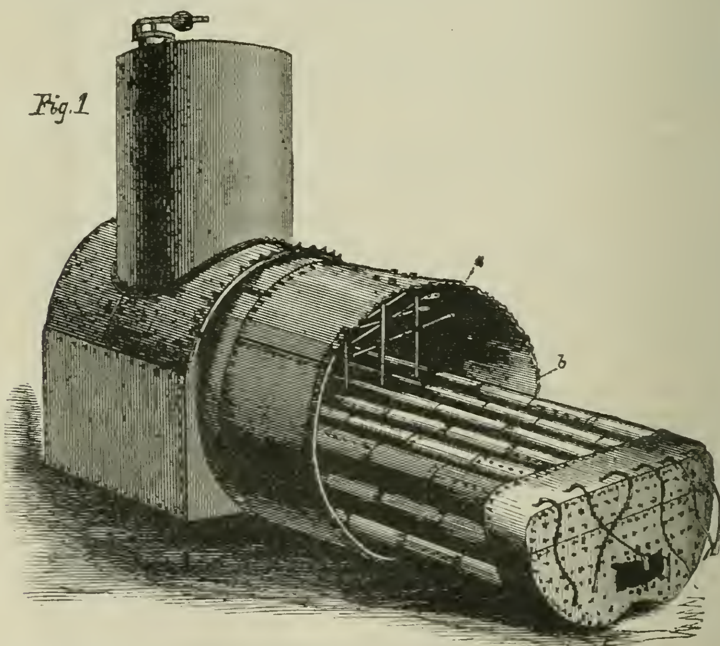
On visiting the "Westfield," I found the vessel lying at the foot of 12th street, East River, in almost precisely the condition in which she was left by the explosion.

The explosion does not seem to have been one of unusual violence. Far more striking effects have been frequently produced by the explosion of much smaller boilers.

The main deck, forward of the engine, is completely torn up, and the largest portion of it carried forward and lodged upon the bow of the boat, where it covers, and is partly supported by, a part of the "shell," or outer portion of the boiler, which has been thrown directly into the "eyes" of the vessel.

The boiler is of a very usual form, as represented in Fig. 1*, and is known as a "Marine return-flue boiler."

Fig. 1



* We are indebted to the enterprising publisher of our contemporary, the *Iron Age*, for the use of this carefully made engraving of the boiler after the explosion.

The diameter of its shell—the cylindrical part now ruptured—is ten (10) feet; its thickness, No. 2 iron, twenty-eight hundredths (0.28) inch. The lower third has its girth seams double rivetted.

The "fire-box" is of iron, three-eights ($\frac{3}{8}$) inch thick, and from the three furnaces the flame and gases pass to the back end of the boiler through two (2) flues of twenty (20) inches diameter, and eight (8) flues of fourteen (14) inches diameter. The former are of No. 4 iron, twenty-four hundredths (0·24) inch, and the latter of No. 6 iron, two-tenths (0·2) inch thick.

From these flues the flame issues into the back connection where it rises and enters six (6) sixteen (16) inch flues, through which it returns to the fire-box end of the boiler, and then rises through a forty-six (46) inch flue in the steam chimney. The steam chimney itself is about seventy-six (76) inches in diameter and twelve (12) feet high.

The sixteen (16) inch flues are of No. 6 iron, two-tenths (0·2) of an inch thick, and the steam chimney of iron, five-sixteenths ($\frac{5}{16}$) thick.

The "flue-sheets"—*i. e.*, those sheets which support the ends of the flues,—are of No. 2 iron, twenty-eight hundredths (0·28) inch thick, while all parts of the boiler not mentioned are of No. 3 iron, twenty-six hundredths (0·26) inch thick.

The total "fire surface" amounts to fifteen hundred and seventy-four (1574) square feet; the total area of cross section of main flues is eighteen hundred and sixty (1860) square inches, of return flues twelve hundred and six (1206) and of steam chimney flue sixteen hundred and sixty-two (1662) square inches.

Of the fire surface above described, rather more than one-half, or about eight hundred (800) square feet is, by law, considered effective heating surface in calculating area of safety valves.

The boiler is broken into three parts.

The first, and by far the largest part, consists of the furnaces, steam chimney and flues, with a single course of the shell; the second consists of two courses of the outside of the shell next the back head, together with that head, to which they are still attached; the third piece consists of a single complete course from the middle of the cylindrical shell, which has been separated at one of its longitudinal seams, partially straightened out and flung against the bottom and side of the boat.

This last piece lies directly opposite its original position in the boiler before the explosion, while the first and second pieces have gone in opposite directions, the former now lying several feet nearer

the engine than when *in situ*, and against the timbers of the "gallows-frame," while the latter piece has been thrown fifty feet forward into the bow of the boat, where it now lies, torn and distorted.

The longitudinal seam, along which piece number three separated, will be shown you, and the deep score or "channel," cutting nearly through in many places, and presenting every evidence of being an old flaw, will be pointed out. The mark made by a chisel in chipping, and that of the caulking tool, may be seen and indicate the probable initiative cause of the flaw.

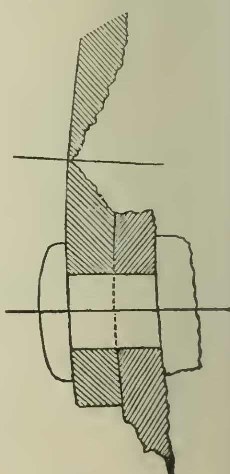
Measuring from the man-hole—which is found in this sheet, and which was originally at the top of the boiler,—to the fractured seam, shows it to have been upon the right hand side, facing forward, and about three feet below the middle line of the boiler.

The position of this piece indicates, evidently, that it was thrown off *first*, as otherwise it must have been dragged either forward by piece number two, had the girth or vertical seam nearest the fire-box given away first, or it would have been carried toward the engine by number one, if that seam had not parted until after the girth seam next forward and on the other side of number three.

Experts may differ in regard to the point of first rupture along this sheet.

I have examined this piece carefully and find an old crack or "channel" cut along the edge of the horizontal tap referred to as now being at the ends of the sheet as it lies, and in some places so nearly through that it is difficult to detect the mere scale of good iron left, while in other places there remains a sixteenth ($\frac{1}{16}$) of an inch of sound metal. Fig. 2 exhibits a section of the crack.

(Fig. 2.)



Were this the weakest place in the boiler, and the *least thickness* here (one sixteeth ($\frac{1}{16}$) of an inch,) the tensile strength being equal to the average determined by the tests to be described, the pressure required to rupture such a boiler, ten feet in diameter, would be $44079 \times \frac{1}{16} \times 2 \div 120 = 47$ lbs. per square inch nearly.

A pressure of twenty-seven (27) or twenty-eight (28) pounds would burst it open where the least thickness was slightly more than one thirty-second ($\frac{1}{32}$) of an inch. It should be remembered that one portion may be supported, to some extent, by a neighboring stronger part.

Along this longitudinal seam the limit of strength would seem to be about thirty (30) pounds per square inch.

The original strength of the boiler was equal to about one hundred and twenty (120) pounds along the horizontal seams, its then weakest parts, provided that the iron had, when new, the average of the specimens which we have tested.

As the boiler was, at the time of its explosion, much stronger at the seams than in the channeled parts, no allowance has been made in the first calculations for loss in riveting.

In the vertical seams may be seen, in some places, similarly weakened portions, the cracks running usually from rivet to rivet, and here and there exhibiting marks that show the wedging action of the "drift-pin," and many places, both in longitudinal and girth seams, are cut by the chisel and marked by the "caulking tool."

The heating surfaces appear uninjured and in good order, and have, here and there, an incrustation of lime that may be due to the occasional use of sea water.

The smoke-stack has been thrown forward into the boat by the recoil aft of the boiler, and the safety-valves were somewhat injured by the blows received.

The steam gauge in the engine room escaped injury.

Examining the iron of the injured portions of the boiler, its appearance was found generally to be that of a fair quality of what is known as "charcoal No. 1," which brand stands next but one, in quality, to the exceptionally good iron known as "best flange iron."

In some places the sheets are made up of laminæ imperfectly welded together, owing to the incomplete exclusion of impurities while in process of manufacture.

This is an imperfection of frequent occurrence, but it rarely seriously reduces the tensile strength of the metal. Its quality will be better understood after examining the results of the formal tests.

The iron retains almost its full thickness except in certain lines such as I have described, or in spots of limited area where patches have been applied in several instances.

After examining the boiler I associated myself, as directed, with Messrs. Andrew Fletcher, Chas. W. Copeland and W. W. Vanderbilt, the Board of Experts appointed for the purpose by Supervising Inspector Addison Low, and proceeded with them in the examination of the steam gauge and safety-valves of the "Westfield," and in testing iron from the boiler.

On examination of the steam gauge, I found it to be No. 25,191 of the Am. Steam Gauge Co's make, with a scale ranging up to sixty (60) pounds per square inch. We tested this gauge by comparison with a carefully measured mercury column, up to thirty-five (35) pounds pressure, and it was found practically correct, the difference in reading at twenty-five (25) to twenty-seven (27) being less than a half pound, and the maximum degree of variation being, at very low pressures, one and seven tenths (1·7) pounds. This is an unusual degree of accuracy.

The safety valve, as found on the boiler, had been so badly injured by the explosion as to require the straightening of the lever and of the valve stem before it could be tested. This having been done, the weight was placed at a point upon the lever, twenty and one-half ($20\frac{1}{2}$) inches from the valve stem, where a chisel mark could be seen on each side of it. It then blew off at twenty-four (24) to twenty-four and a half ($24\frac{1}{2}$) pounds of steam. The weight was then placed six (6) inches further towards the end of the lever, at which point the Board found it before the removal of the valve from the boat, and in this position it allowed steam to blow off at twenty-eight (28) pounds. A third trial was then made with the weight as far out on the lever as it would go; steam then blew off at thirty-one (31) to thirty-three (33) pounds pressure, this being the maximum at which it can retain steam entirely. This valve has a diameter of five and a half ($5\frac{1}{2}$) inches, and an area of twenty-three and three-quarters ($23\frac{3}{4}$) square inches.

The valve must lift nearly one and a half ($1\frac{1}{2}$) inches to obtain its full opening, but, on trial, when *set* at twenty-seven (27) pounds, it lifted only a quarter ($\frac{1}{4}$) of an inch when the steam in the boiler exerted a pressure of forty-five (45) pounds.

The "government" or "lock-up" safety valve was next tried. This is called the "American valve." It is three (3) inches in diameter and has an area of seven (7) square inches. Were the main safety valve to stick in its seat, as frequently happens, this valve would be of little use, with steam rising rapidly. No engineer would consider so small a valve, on a boiler of this size, to be, in a proper sense, a "*safety* valve."

This valve, with the weight set at twenty-seven (27) pounds by the scale on the lever, blew off at thirty-two (32) by the test gauge. It

may possibly have been sufficiently injured by the explosion to cause this discrepancy.*

The remaining test, by the Board, was that of the iron of the boiler. Twelve pieces were cut from the course thrown from the middle of the boiler, and were numbered Nos. 1 to 6, inclusive, were cut crosswise the sheet, and 7 to 12, inclusive, lengthwise. Each of these pieces was reduced, at the smallest part, to an area of cross section as nearly equal to one-sixth ($\frac{1}{6}$) of an inch as was possible, and the exact section was then measured accurately, the greater dimension by a Darling, Browne and Sharpe Vernier Scale, reading to thousandths of an inch, and the smaller by a Browe and Sharpe "Micrometer Thickness Gauge," of equal delicacy.

Each piece was then broken with the following result:

	Original		Breaking	Ditto per	Fractured		Break'ng weight per inch.
No.	Breadth.	Thickn's.	Weight.	Square Inch.	Breadth.	Thickn's.	Fractured area.
1	0·544	0·299	6260	38475	0·545	0·295	38939
2	·552	·295	7000	43000	·536	·288	45336
3	·534	·294	surged,	no test.	·542	·285	
4	·555	·295	6200	minimum 37874	·544	·288	39556
5	·554	·293	6400	39433	·546	·289	40558
6	·553	·296	7260	maximum 45890	·545	·280	47575
7	·548	·296	7264	44784	·530	·283	48428
8	·553	·292	7000	43344	·525	·271	49193
9	·553	·310	7440	43409	·525	·273	51919
10	·554	·286	7450	47879	·526	·270	52514
11	·544	·299	6754	minimum 41512	·520	·274	47397
12	·544	.285	7680	maximum 49548	·522	·270	54507

Average across " grain" 40934 lbs. per inch of original area, 42718 on fractured area.
" with " 45079 " " " 50623 " "
" extension before breaking, 0·035 across the grain, 0·124 along the grain.

The broken pieces were then bent cold on an anvil to further test their quality.

I also sent a piece of the same iron to Professor Albert R. Leeds, Chemist of the Stevens' Institute of Technology, with a request that he would determine its specific gravity, which should be about seven and seven-tenths (7·7), a higher figure indicating a fine quality, and

* At the inquest, the engineer (Conolly), who set it under the direction of the U. S. Inspector a short time before the explosion, stated that it was set at 20 or 21 *by the scale*, blowing off at 26½.

a lower, the reverse, provided that the inward range is restricted within certain limits.

Prof. Leeds reports as follows:

STEVENS' INSTITUTE OF TECHNOLOGY,
Hoboken, N. J., August 11th, 1871.

Sir:—I have made two determinations of the specific gravity of iron taken from the exploded boiler of the "Westfield," and have obtained the same result, viz., 7·6 at 79° Fahr.

Very respectfully,
(Signed) ALBERT R. LEEDS.
Prof. R. H. Thurston. *Professor of Chemistry.*

Selected "Pennsylvania flange iron," sent to the Washington Navy Yard for trial, broke at from fifty-six thousand (56,000) to sixty thousand (60,000) pounds per square inch tensile strain, but such quality is seldom put into the shell of a boiler, it being usually reserved for parts more difficult to work or more liable to injury, as the furnaces, flue sheets and parts greatly exposed, either to action of flame or of external moisture.

Prof. Rankine, a leading English authority in engineering matters, gives "boiler plate, strong, 50,000."

Chief Engineer, Wm. H. Shock, U. S. Navy, who has had an unusually large experience with American irons, reports* that samples cut from rolled bars, furnished under contract, gave an average of fifty-nine thousand, one hundred and ninety (59,190) lbs. per square inch lengthwise, and fifty-three thousand one hundred and sixty-three (53,163) across the bar. Bar iron is usually stronger than plate.

Chas. Haswell, another eminent American authority, gives the strength of boiler plate† as fifty-three thousand eight hundred (53,800) lbs. lengthwise, and forty-eight thousand eight hundred (48,800) lbs. per square inch across the grain.

The irregularity of the iron from the "Westfield" indicates either a weakening effect from the wrenching and twisting produced by the explosion, or from its laminated structure; its low tensile strength, even at its maximum, and its low specific gravity, lead to the same conclusion, while its behavior and appearance, when subjected to the test of breaking cold, indicate that the metal itself was of good quality, although made into sheets of but medium value, and its extension under the breaking strain also confirms this conclusion.

* Journ. Franklin Institute, 3d series, vol. 59, p. 221.

† Ibid, 3d series, vol. 40, p. 338.

Having stated the facts ascertained, and the conclusions arrived at during my investigation in company with the Board of Experts, I will next consider, so far as it is proper, the causes that may lead to the explosion of steam boilers. These causes are now well understood by professional engineers. The thorough examinations and investigations resulting from thorough and systematic inspection of boilers both in our own country and abroad, have shown as conclusively as any scientific fact can be proven, that the explosion of a steam boiler may be invariably ascribed to some very simple and perfectly natural cause.

* * * * * * * * *

In fact, the causes of explosion are now so well understood as to be a matter of business calculation, and the " Boiler Insurance Companies" here and abroad take risks upon them, with far more power of controlling their losses by frequent and careful inspection, than have fire insurance companies.

Systems of inspection, both public and private, have done much, and may be expected to do more to reduce the frequency of these " accidents," even if they do not finally prevent them altogether.*

* * * * * * * * *

In this connection it becomes my duty to state how repairs may be necessitated by the action of oxidation or corrosion in its various forms.

Corrosion may affect a single spot in a boiler, in which case a "patch," if properly applied, should make the boiler nearly as strong as when whole.

A series of weak spots near each other may so weaken a boiler as to produce explosion, as may any considerable area of thin plate, although, when occurring in the stayed surfaces of a fire-box, the metal may become astonishingly thin. A sketch of spots of corrosion is shown in Fig. 3, which represents the cause of an actual explosion.

This cause of explosion may be either internal or external, and is induced internally by bad feed water, and externally by dampness or by water leaking from the boiler, either unseen or neglected. It is always dangerous to have any portion of a boiler concealed from frequent observation.

* Here follows a statement of the various causes of explosions and an *exposé* of some prevalent absurd theories on the subject, which were useful to a jury of non-professionals, bnt not to our readers.

Another form of corrosion is variously termed "grooving," "furrowing," and "channelling," and this is also a frequent cause of explosion. In this case the boiler is scored deeply, as by a tool of some kind, along the border of a seam, or where there occurs a sudden change of thickness of metal. These channels are sometimes

Fig. 3.

continuous, and sometimes interrupted by portions of good iron. They are probably caused by changes in form of the boiler with variations of temperature and pressure, some line of local weakness determining the line along which the plate shall bend, and this bending taking place continually, though ever so slightly, along the same line precisely, finally produces rupture.

Sometimes this action produces a narrow crack, and at other times, as the rust formed is thrown or scoured off the iron at the bend, leaving a comparatively clean surface, oxidation is probably accelerated, and the fault takes the form of a groove or furrow. If unperceived, this goes on until a rupture or an explosion occurs. Fig. 4 exhibits such a case, and represents the cause of an actual explosion.

This *change of form* in the boiler may proceed from either of the following causes, which act continually throughout the life of a boiler:

Changes of temperature occur as steam is raised or blown off from a boiler, and, when carrying twenty-seven (27) pounds of steam, its temperature becomes two hundred and seventy-three degrees (273°) Fahr., from which temperature it falls to that of the atmosphere each time that steam is blown off. It will change its form more or less, and will usually be subjected to some strain by this process.

Again, while actually at work, the steam space and upper portion of the water space are at the temperature of steam at the working pressure, while the lower part is continually varying in temperature from that of the feed-water to the maximum which it attains after entrance. This difference of temperature between the upper and lower parts of the boiler, as well as between other portions, causes a continual tendency to distortion, and, if this distortion be resisted, a stress is thrown upon the parts equal to that which would be required, acting externally, to remove the distortion, if produced. The stress is also equal to the mechanical force that would be necessary to produce similar distortion.

Thus, had the temperature of the main and upper part of the "Westfield's" boiler been, after the entrance of the feed-water, two hundred and seventy-three degrees (273°), or that due to about twenty-seven (27) or twenty-eight (28) pounds steam, while the feed-water had a temperature of seventy-three degrees (73°),—which happens to be the temperature of the hydrant water at the Stevens Institute of Technology as I write,—the bottom of the boiler having a temperature, in consequence, two hundred degrees (200°) below that of the top, the difference in length would be about one eight hundredth ($\frac{1}{800}$) and, if confined by rigid abutments, iron so situated would be subject to a stress of twelve and a half ($12\frac{1}{2}$) tons per square inch. But, in this case, one part would yield by compression and the other by extension, and if they were to yield equally it would reduce the stress to six and a quarter ($6\frac{1}{4}$) tons. Actually, in this case, the lower fourth and upper three-fourths would be more likely to act against each other, and the stress, *if the boiler had no elasticity of form*, would be about nine (9) tons. Any elasticity of form—and boilers generally possess considerable—would still further reduce the strain, and it very frequently makes it insignificant.

Again, I have assumed the worst possible case, the line of separation between the hot and cold parts being perfectly defined, instead of, as is actually the case, there being a gradual change of temperature from the bottom to a point some distance above, where the maximum temperature is usually attained, and the effect is thus very greatly and very favorably modified in most instances.

It is, however, evident that, acting on worn and weakened boilers, and on those that are deficient in elasticity of either material or form, or when acting to strain a seam already injured by the use of the "drift pin," or by careless workmanship in other respects, or again

where unanticipated and unprovided for forces act with it, serious results may be produced, and in fact, such results have actually occurred in isolated cases, with even new boilers.

The action just described affects only the vertical or "girth" seams of the "Westfield's" boiler. An assisting stress also arose in this case, from insufficient support apparently.

Another, and with boilers of large diameter like this, an important cause of variation of form and consequently of "channelling," is found in variations of internal pressure. This would affect principally the horizontal seams.

When the cylindrical shell, ten feet in diameter, was empty, it had a tendency which must, to some extent, have produced an effect to flatten down, taking an elliptical cross section, which action would be of greater extent as the boiler was filled with its great weight of water when steam was raised, its pressure assisted the elasticity of the iron in the effort to restore the cylindrical form, and thus, with all changes of weight and pressure, the boiler would be changing its form in such a manner as to affect the horizontal seams, as the changes of temperature already described affect the other seams, and produce channelling. Here a horizontal seam actually gave way. In either direction, this form of corrosion might be initiated by the previous existence of lines of weakness. Such lines exist in the "Westfield's" boiler, produced by careless or unskilful use of the chisel and the caulking tool. Part of the boiler have been removed and will be placed before you, and you will be able to exhibit to the jury the ends of the middle course of plates which blew off against the side and bottom of the boat, and also a part of another adjacent and similarly situated seam which shows, also, a similar channel or crack. The latter also illustrates that maladjustment of rivet holes, which was formerly, even by good engineers, considered to justify the use of the drift pin.

The steam gauge, the safety valves, and the pieces of iron cut from the boiler and tested, will also be brought in. The latter are all carefully marked with the weight at which they broke, and with a line indicating the direction of the "grain of the iron."

I omit all reference to the inspection of boilers as a means of preventing explosions, as I do not think it is required by my instructions, and because I expect that it will be very fully considered on the inquest by the Experts whom you have summoned, the possibility of any inspection detecting the weakness of the "Westfield's" boiler, being one of the principal subjects of your investigation.

I trust that the facts that I have presented will be found useful by assisting you so to direct your inquiries as to determine fully the cause of a disaster by which a hundred lives were destroyed, and I also hope that your examination may have a further result in aiding the members of my profession in the effort to secure immunity from such calamities in future.

I have endeavored to present essential facts only, and to make my statements clearly, simply and without prejudice.

Very respectfully,
(Signed) R. H. THURSTON,
Professor Mechan. Engineering.

Coroner P. H. Keenan,
11 City Hall, New York.

The weight of evidence both before the Coroner and before the official Board of Inquiry—convened to determine how far the Inspector, who had passed the boiler on the 12th of June previous, was responsible for the explosion—indicated that the explosion occurred in consequence of the existence of lines of channelling and long existing cracks, by which the boiler was so weakened that, on the 30th of July, the pressure of steam being allowed by the engineer to rise somewhat above the pressure allowed by the Inspector, the boiler was ruptured, giving away along a horizontal seam and tearing a course out of the boiler; the thus separated parts of the shell were thrown apart as described in Prof. Thurston's report.

The testimony indicated very decidedly, the inefficiency of the "hydrostatic test" and the value of the "*hammer test*" *in experienced hands*, in detecting all classes of defects. In this case, it seems very nearly certain that the boiler had been strained at the channelled parts by the water pressure, without awakening even a suspicion in the mind of the Inspector of their existence, doing actual injury and having not the slightest compensating good result.

It was also shown that the U. S. Inspectors had been in the habit of doing their work very carelessly in many cases. It is, however, expected that, under this unexpected stimulus and under the vigilant eye of Inspector General Belknap, who has entered upon his duties since this sad event, a thorough reform and an effective system will be inaugurated.

The verdict of the Coroner's jury inculpates the officials of the ferry company, and prompt action has been taken against them by the proper authorities of both New York and Brooklyn.

A Coroner's jury has since brought in a verdict inculpating the Inspector who passed the worn-out boiler of the tug "Starbuck," which exploded in New York harbor.

Such prompt and earnest action will undoubtedly have a good effect in impressing the officers of steamers and the U. S. Inspectors with the magnitude of the responsibility resting upon them, but we cannot hope for immunity from such calamities until the law is so amended as to compel the U. S. Inspectors, and all Inspectors in fact, to make, at least, quarterly inspections, and to use a light hammer in searching for defects in every sheet and along every seam, and to make provision, also, for keeping constantly in training a large body of Assistant Inspectors, of sufficient experience to be able to detect infallibly every such case as the *Westfield.*

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 176.)

In a former article the difference between English and American machine construction, with some of the reasons that govern it, was briefly alluded to. This branch of the subject should, no doubt, have occupied a greater share of the matter that has appeared, for without an understanding of the very different conditions of the market in which the machines are sold, and the purposes to which they are applied, we can expect no fair criticism of the designs that have appeared of English wood-cutting machines.

We will further say, that in the course of these articles the subject of wood-cutting machines has to be considered in reference to general use, and without assuming any local standard to determine their merits. The correctness of this will not be questioned when we consider how various are the requirements in different countries, which brings us to difference between English and American machines as shown in the engravings which have appeared in the *Journal.*

In the United States the manufacture of wood-machines is almost exclusively for our own use, and nearly all can be fairly considered as special machines. While there is some analogy between the wants of most other countries in this kind of work, America is an exception, the conditions being totally different. Here money is scarce, labor is dear and skill is plenty. Contrast this with the countries where English machines find a market, and we find almost an opposite set of con-

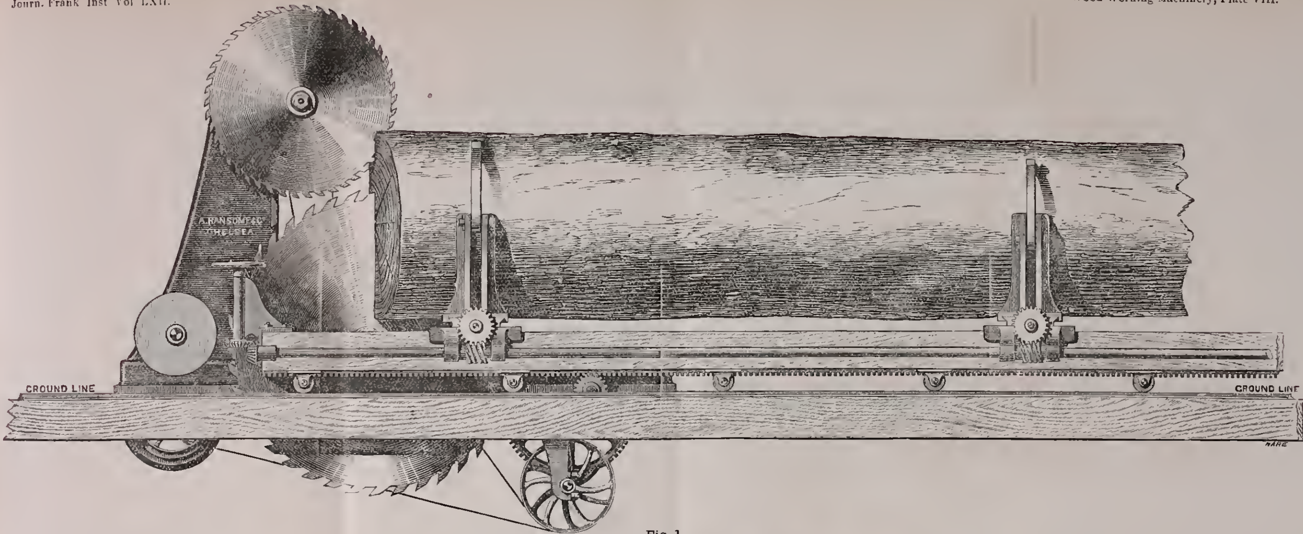

A. RANSOME & Co
CHELSEA
GROUND LINE
GROUND LINE

Fig. 1.

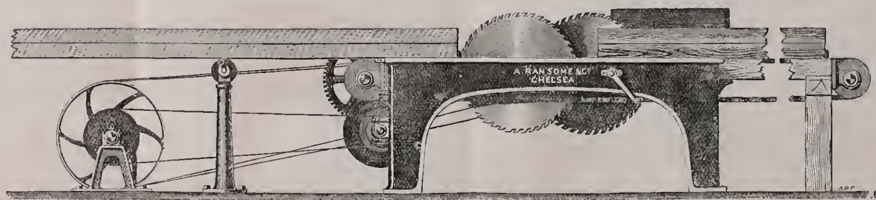

A. RANSOME & Co
CHELSEA

Fig. 3.

A Corone
spector who
exploded in
Such pro
fect in imp
with the m
cannot hop
amended as
to make, at
searching f
make provi
of Assistan
infallibly ev

A treatise on

In a forı
machine co
briefly allu
occupied a
an underst
which the
applied, w
appeared o
We will
of wood-cu
use, and v
merits. T
sider how
brings us t
shown in t
In the U
exclusively
as special
of most otl
the conditi
dear and sl
lish machii

ditions—money commanding a low rate of interest, labor cheap and a want of skill. This, with the difference between the timber of America and that of other countries, accounts for all and even a greater difference than we find between the machines as illustrated in these articles.

In speaking of this general difference in the character of the machines there is no desire to evade the charge of bad designs and want of workmanship that has been so often applied to American wood-machines; they certainly deserve it, as a rule, the fact being that they do not, in any degree, represent American engineering skill, which in other branches has attained a reputation that is fast creating a market for our products in the old world.

Plate VIII, Fig. 1, represents a lumber-mill, from the designs of Messrs. A. Ransome & Co., the manufacturers, being a true side elevation on a scale of $\frac{1}{24}$th.

The general construction conforms to that of the American "Circular Saw-mill," with a "top saw." It is, however, more strongly framed, and the design is a good one. The simultaneous setting device contains a hint for mill men in the tangent wheels for moving the "dogs;" the tensional strain upon the setting shaft will, under this arrangement, be so inconsiderable that the two "heads" will "set true" at any distance apart.

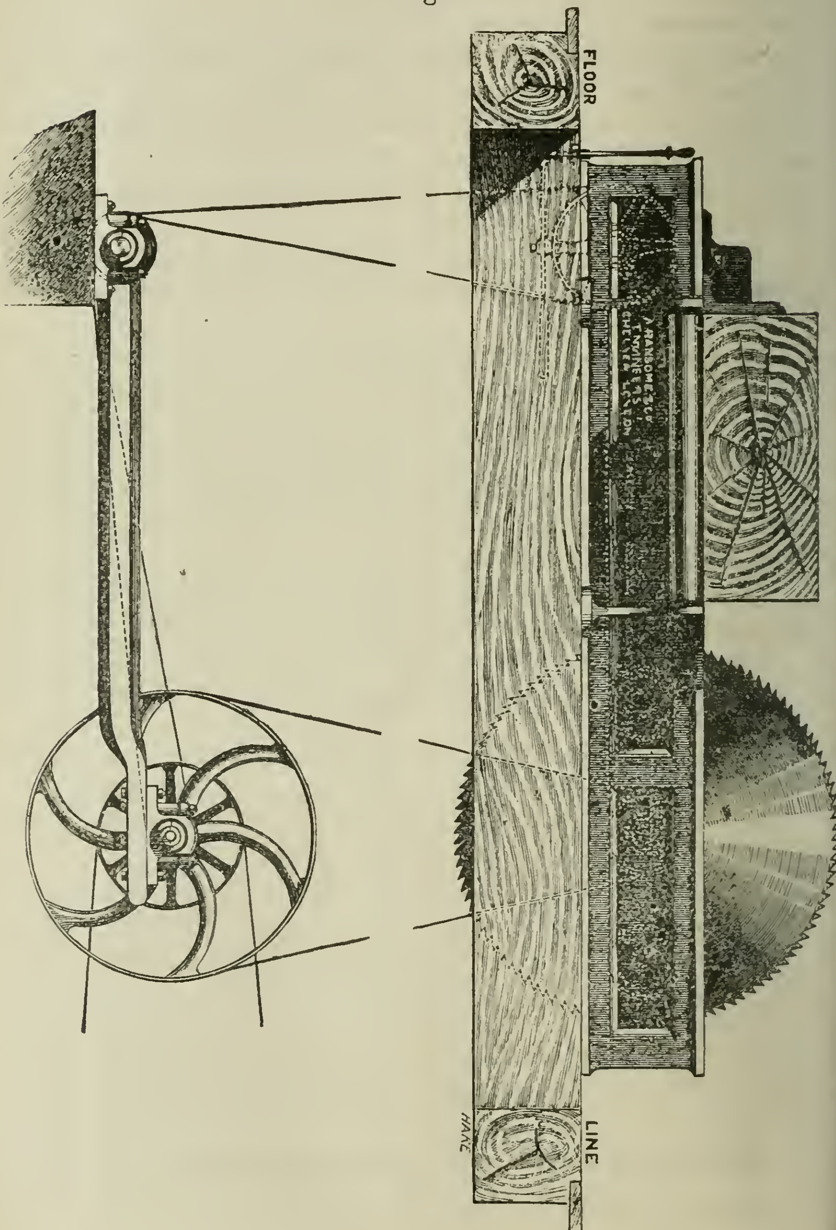
This, that we would term a lumber-mill in America, is, for some strange reason, called a bench in England. The weight is from three to four and one-half tons, exclusive of wood framing; the forward feed is from 10 to 40 feet, with a return motion of 80 feet, per minute.

Fig. 2 represents a cross-cutting machine, by the same manufacturers. The engraving is so perfect that no special description is required. Scale of the drawing is $\frac{1}{24}$th, the weight four tons, capacity eighteen inches deep and forty-two inches wide.

The double "edging" saw shown at Fig. 3, by the same manufacturers, is a machine that could be advantageously used in our mills in this country. The feed is continuous, by means of the chain shown on the right, with a feed of from forty to eighty feet per minute. The space between the saws is regulated by a cross screw and handle, as shown, and the whole fitted up in a good and substantial manner. The practicability of operating two saws parallel with each other may be by some called in question, which, in an ordinary wooden frame and without saw-packing, would be an "open question." It might be suggested, however, that the trouble met with should not exceed that

which is experienced with one of the long saw-gauges that we see in common use, that extends past the plate, and even the whole length of the bench in some cases.

Figure 2.



NOTES ON SPRINGS.

By J. H. Cooper.

Elasticity of Spiral Springs.—"In order that spiral or helical springs may be accurate for measuring forces, the figure of the spring should be a true helix.

"It is more favorable to accuracy to measure a force by the extension than by the compression of a spiral spring.

"The pair of equal and opposite forces by which a spiral spring is stretched, should act exactly along the axis of the helix. The best form of section for the wire of which the spring is made is circular, because the extension of the spring depends on the torsion of the wire; and the laws of torsion are known with greater precision for a circular form of section than for any other.

"The following formulæ show the relations between the load and the extension or compression of the spring:—

"Let r be the radius of the cylinder containing the helical center line of the spiral spring, as measured from the axis to the center of the wire; n, the number of coils of which the spring consists; d, the diameter of the wire; C, the co-efficient of rigidity or transverse elasticity of the material; f, the greatest safe shearing stress upon it; W, any load not exceeding the greatest safe load; v, the corresponding extension or compression; W_1 the greatest safe *steady* load; v_1 the greatest safe extension or compression; then

$$\frac{W}{v} = \frac{c\,d^4}{64\,n\,r^3}; \quad W_1 = \frac{0.196\,f\,d^3}{r}; \quad v_1 \frac{12.566\,n\,f\,r^2}{c\,d}.$$

"The greatest safe *sudden* load is $\frac{W_1}{2}$.

"If the wire of which the spring is made is square, and of the dimensions $d \times d$, the load for a given deflection is greater than for a round wire of the diameter d, in the ratio of 281 to 196, or of 10 to 7, nearly.

The values of the co-efficient, C, of transverse elasticity of steel and charcoal iron wire, in lbs., on the square inch, range between 10,500,000 and 12,000,000.

"By the greatest stress is to be understood the greatest stress which is certain not to impair the elasticity of the spring by frequent repetition: say 30,000 lbs. on the square inch.

"The value of the ratio $\frac{W}{v}$ borne by the load to the extension,

ought to be ascertained by direct experiment for every spring that is used in dynamometers or indicators."—*Rankine's Millwork*, p. 389.

"The best form of longitudinal section for each spring is that which gives the greatest flexibility for a given strength, and consists of two parabolas, having their vertices at two ends of the spring, and meeting base to base in the middle: that is to say, the thickness of the spring at any given point of its length should be proportional to the square root of the distance of that point from the nearest end of the spring. To express this by a formula, let

c be the half length of the spring;
h the thickness in the middle;
x the distance of any point in the spring from the end nearest to it;
h' the thickness at that point; then

$$h' = h \cdot \sqrt{\frac{x}{c}}$$

"The breadth of each spring should be uniform, and, according to General Morin, should not exceed from $1\frac{1}{2}$ to 2 inches. Let it be denoted by b.

"The following is the formula for calculating beforehand the *probable* joint deflection of a given pair of springs under a given tractive force:—

"Let the dimensions, c, h, b, be stated in inches, and the force, P, in pounds.

"Let y denote the deflection in inches.

"Let E denote the *modulus of elasticity* of steel, in pounds on the square inch. Its value for different specimens of steel varies from 29,000,000 to 42,000,000, the smaller values being the most common. Then

$$y = \frac{8\,\mathrm{P}\,c^3}{\mathrm{E}\,b\,h^3}$$

"The deflectiou should not be permitted to exceed about one-tenth part of the length of the springs."—*Rankine's Millwork*, p. 386.

Rules for proportioning spring plates.—"The theory of the resistance of materials to flexure, according with the known results of experiment, shows that when a metallic plate of a constant rectangular section is fastened at one end, and subjected at the other to the action of an effort P, perpendicular to its length or primitive direction; or when an elastic plate of the same form is placed freely upon two

supports, and subjected in the middle to an effort P, directed in the manner described, its flexure, F, so long as it does not exceed the limits of elasticity, will be:

"1st. Proportional to the effort P;

"2d. Proportional to the cube of the arm of the lever *c* of this effort;

"3d. In an inverse ratio of the width *a* of the plate, in a direction perpendicular to the plane of flexure;

"4th. In an inverse ratio of the cube of the depth *b* of the plate, at the fixed point for the first case, and at its middle for the second;

"5th. In an inverse ratio of a number E constant for each body, called the co-efficient or *modulus of elasticity*, and which expresses in pounds the weight required to extend a prismatic bar of the same material, with a unit of surface, for its transverse section, to double its primitive length, if such change in its dimensions may be made, without varying the value of E.

"Furthermore, if the longitudinal profile of the plate presents the parabolic form of solids of equal resistance, the flexure will be double that of a plate of uniform thickness throughout its length, subjected to the same efforts; while the resistanee to rupture is the same in both.

"Hence, we have for springs for equal resistance, conformably to theory and experience, the relation

$$f = \frac{\mathrm{P.\ C}^3}{\mathrm{E.}\ a.\ b.^3},$$

A formula, by means of which we can calculate any one of the quantities composing it when the others are known. I have found in the construction of many spring plates, that if made of good German steel, properly tempered and annealed, the value of the co-efficient of elasticity to be used will be

$$\mathrm{E} = 4273700000 \text{ pounds per square foot.''}$$

Ratio to be established between the different proportions.—"The width *a* of the plate should, at most, not exceed the limit of from ·1312 feet to ·164 feet, since the warping produced by tempering increases with its width, and creates difficulties in its adjustment.

"An examination of the springs which I have made, shows that the flexures of springs remain proportional to their efforts, when for the strongest they do not exceed $\frac{1}{10}$ of their length, and for the weakest $\frac{1}{9}$, the measure being taken from the place where they are embedded.

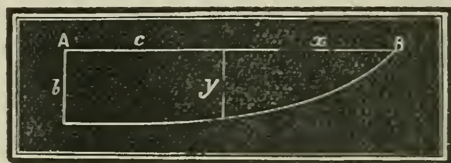
"With these data it will be easy to calculate the thickness b to be given to the plate at the place of its setting, so that under a determinate effort it may take a known flexure. It is derived from the following formula:

$$b^3 = \frac{\mathrm{P}\,c^3}{\mathrm{E}\,a\,f}.$$

Longitudinal profile of the plates.—"The above dimensions being obtained, we determine the form of the longitudinal profile by means of the formula:

$$y^3 = \frac{b^2}{c}\,x$$

In which b and c being the quantities already designated,



x will represent the abscissa of the curve measured from its origin B. and y will be the corresponding ordinate."—*Morin's Mechanics.—Bennett*, 1860, p. 34.

In order to test the effect of compression on springs of the conical volute form, made of steel strips of rectangular section bent flatwise, and afterwards tempered in oil, I had a spring made of a piece of steel 1 inch wide, 6 feet long, and No. 14 wire gage thick. This was first formed into a flat volute, having an outside diameter of $4\frac{3}{8}$ inches and an inside aperture of $2\frac{7}{8}$ inches, the band of steel making 7 turns. The spring thus made was drawn out $2\frac{5}{8}$ inches, thus making a conical volute whose entire height was $3\frac{5}{8}$ inches.

The compression due to certain weights will be found in the following:

Height of spring in inches.	Wts. in lbs. applied.
$3\frac{5}{8}$	0
$3\frac{1}{4}$	5
$2\frac{7}{8}$	10
$2\frac{3}{8}$	15
$2\frac{1}{8}$	20
$1\frac{1}{2}$	25
1	30

Another made of steel 1 inch wide, No. 14 and $6\frac{1}{4}$ turns, tempered in oil, and same diameter, gave the following:

$5\frac{1}{2}$ inches high.	0 lbs.
$4\frac{1}{2}$ " "	10 "
$3\frac{1}{2}$ " "	20 "
$2\frac{1}{2}$ " "	30 "
$1\frac{1}{2}$ " "	40 "

Rule for the strength of Locomotive springs:

$$L = \frac{B\,T^2\,N}{11 \cdot 3\,S} \qquad N = \frac{11.3\,S\,L}{B\,T^2}$$

In which S = span of spring, in inches.
B = breadth of plates, in inches.
T = thickness of plates, in sixteenths of an inch.
N = number of plates.
L = safe load on spring, in tons.

Molesworth Pocket Book, 1865.

Springs.—The flexure of a spring is proportional to its load and to the cube of its length.

Deflection of a carriage spring.—A railway carriage spring, consisting of 10 plates $\frac{5}{16}$ in. thick, and 2 of $\frac{3}{8}$ in. thick; length 2 feet 8 in.; width, 3 in., and *camber* or spring 6 in., deflected as follows, without any permanent set: $\frac{1}{2}$ in. under a half ton; 1 in. under one ton; $1\frac{1}{2}$ under one and a half tons; 2 in. under two tons; 3 in. under three tons, and 4 in. under four tons.—*Haswell*, 1867.

(To be continued.)

THE OVERFLOW OF THE MISSISSIPPI RIVER.

By D. S. Howard, C. E.

The recent New Orleans flood is another reminder of the neglected laws that govern the action of water over beds and between banks of yielding material. Like all other calamities, it is calculated to draw our attention to precautionary measures against the recurrence of other similar disasters.

It would seem to be too plain to require repetition, that the temporary effect of the Levee system, for promoting the overflow of the Mississippi banks, is worse than useless. The rise of the bed of the river is as sure to follow every freshet, which is confined within its banks, as it is that the freshets bring down sediment that is not disposed of by crevasses, rendering the section of the stream less than the capacity required by the next freshet, consequently requiring increased height and strength of levee every year.

It may not be clear to every person, how the sediment should be deposited more by freshets than by a less flow of water, on the same bed. But there is more sediment in a freshet than in low water, which is deposited more readily in proportion to the difference between the inclination of the surface of the water in a freshet, and in low water, with regard to the inclination of the river bed, which is the same in both cases. The rise in the water being greater above than at the mouth, to give the necessary velocity to dispose of the surplus water of a freshet, confined within limited banks, increases the inclination of the surface, while the bed remains the same; it also increases the section of the stream more above than below. This, together with the action of gravity on the water with increased motion and inclination of surface, and consequent greater reaction on the bed, has the effect to diminish the motion of water nearer the bed of the stream, and throw down more sediment than will be deposited when the bed of the stream is nearer parallel with the surface.

Whatever difference of opinion may exist about the theory, the fact has been established by experiment that the motion of water near the bed of streams is less in freshets than in low water. Common observation also teaches us that the beds of the lower waters of all similar streams to the Mississippi, where the freshets are confined within the limits of their low water banks, are annually rising. With these facts in full view, it seems easy to comprehend the necessity of adopting some other means of avoiding all similar catastrophes by looking towards the source of the evil instead of confining our gaze on the evil itself. By such a deviation from the too common course, we shall soon see that freshets may be arrested near where they originate, much easier than they can be confined, after a combination of a large number of tributaries have collected their forces and concentrated them on a main outlet like the lower Mississippi.

By the selection of proper sites for reservoirs at or near the head waters of rivers, it is very easy to see that much less expense of dams will prevent a freshet than will prevent an overflow of the lower river banks by levees.

The argument against reservoirs is the danger of breaking away, of which there is no necessity whatever, if properly planned and constructed. If the reservoirs be numerous, as they must needs be on the Mississippi, it would not be at all probable, in any event, that all would break at the same time, or enough to do any harm; whereas, the dykes, being necessarily more extensive, are proportionably more

liable to break in some part of the two long lines, always doing more or less damage, according to the extent of the freshet and the location of the breach, without the possibility, sometimes, of repairing the crevasse until the freshet subsides; while a reservoir dam may be immediately repaired, ready to check the torrent in case of any other similar accident.

Many of the reservoirs may be located as to be worth more than their cost for the water power they would provide, but the greatest advantage to be derived from them on the Mississippi River would be the benefit to navigation, by affording more water in a low time, and preventing the accumulation at the mouth, which is now the effect of every freshet.

It is now well known that the bar at the mouth of the Mississippi is the worst at the time of the highest freshets, affording the least depth of water for the entrance of ships. But the low season allows the salt water to flood the bar, and float up the new deposit made on the clean washed low water bed, in the shape of what is called "mud lumps," from the greater weight of the salt water to that of the newly deposited sediment, assisted, perhaps, by fermentation of vegetable matter contained in the sediment, during the hot season, subsequent to the freshet; after which there is a greater depth of water over the bar, until another freshet has forced the heavy salt water from the location, when another bar is formed as before.

This consideration alone should be sufficient to induce any Government, with competent foresight, to institute an inquiry, at least, calculated to solve the mystery of the right plan for overcoming the great evil attending the uncontrolled freshets of the Mississippi River, which would also provide a specific for the freshets on all similar streams as well.

No investment of public lands or public money could be made that would afford the same returns as the permanent improvement of the Mississippi and its tributaries by the Reservoir system. This plan has the uncommon merit of being progressive.

When a reservoir is properly constructed, it is a permanent improvement as far as it goes, whether the system be extended or a return to any other system be adopted, it works equally well; therefore, if the estimates of the engineer in charge be not satisfactory, an experiment may be made without a total loss, as with most experiments. The amount of water withheld from a freshet by a reservoir reduces the freshet and its effects, and the additional levees required,

in exact proportion to the capacity of the reservoir, for all time to come, whether any more be constructed or not; and if the Reservoir system be carried out to its fullest extent on any river like the Mississippi, so as to equalize the flow of water at all times, the stream will soon acquire a fixed regimen; every yielding obstruction to the full capacity of the stream will soon have given way to the continued action of the water, affording an uninterrupted navigation, with a permanent location of the stream, which can be obtained by no other means.

The following are some considerations in favor of the Reservoir system in contrast with the Levee system:

Reservoirs require no additions or repairs from year to year, if properly constructed.

Levees require additions every year, in proportion to the amount of deposit on the bed of the river left by the preceding freshet.

Reservoirs retain the sediment of the freshet in proportion to the amount of water retained, and lessen the accumulation in proportion to the diminished height and velocity of the surface current.

Levees increase the amount of sediment in proportion to the increase of height and velocity of the surface current by the freshet.

Reservoirs create a fixed regimen and location for a stream, when the system is fully carried out, which frees the banks above the surface of the water from abrasion by currents, while the lower banks and bed of the stream are soon washed clean of their yielding particles, producing a uniform pure, clear water stream in all seasons of the year, affording the least amount of material for the bar at the mouth.

Levees, when the most successful, cause the highest freshets and the greatest amount of abrasion of the banks, consequently the most variation in the course of the stream, affording the largest amount of material for the bar at the mouth.

Reservoirs, by promoting the overflow of large surfaces of land in warm climates, lessen the amount of fresh material for miasm, so abundantly supplied by freshets, and so prejudicial to health.

Levees, if permanent, must necessarily expose a large amount of saturated surface, covered with sediment, between the levees, after every freshet, to the action of the sun; but, if not permanent, the disaster to health as well as property is very great.

Richmond, Virginia, 1st July, 1871.

ON THE FLOW OF WATER IN RIVERS AND CANALS.

By J. Farrand Henry, Ph. B.

(Continued from page 173.)

In Table II are given the observed and computed co-efficients of another Telegraphic Meter, much heavier than the last, of the form shown in Figure 4; and of a Woltman's Meter which was tested with the Telegraphic Meter:

Table II.

Velocity in feet per sec.	Telegraphic Meter Co-efficients.			Woltman Meter Co-efficients.		
	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.
1·0					0·493	
1·4		1·322				
1·5	1·171	0·170	+0·001	0·420	0·412	+0·008
2·0	0·961	0·971	—0·010	0·388	0·387	+0·001
2·5	0·868	0·882	—0·014	0·375	0·374	+0·001
3·0	0·852	0·837	+0·015	0·369	0·369	000
3·5	0·840	0·825	+0·015	0·369	0·369	000
4·0	0·833	0·822	+0·011	0·368	0·368	000
4·5	0·819	0·819	000	0·366	0·366	—0·001
5·0	0·813	0·816	—0.003	0·360	0.366	—0·006
5·5	0·808	0·813	—0·005			
Sums			+0·010			+0·003
Mean			+0.0011			+0·0004

These co-efficients were obtained in the same manner as the former, but they decrease much more rapidly at first, so that the same curve cannot be used. It was found that they would best agree with an ellipse having the same minor axis as the other, 3·44; but a major axis only one-half as great, 4·10. The computed co-efficients were obtained in the same manner as those in Table I. After leaving the curve, the observed co-efficients follow a line making a small angle with the tangent.

Unfortunately, there were no observations at high velocities made with the Telegraphic Meters; therefore we cannot exactly determine the law of change of the co-efficients in fast currents; but they probably vary little from the last ones given in the tables.

M. Baumgarten* gives a series of observations to determine the co-efficient of the Woltman meter constructed by him, and used in his velocity measurements in the Garonne. These observations were made both by drawing the meters through still water, and also by

* Annales des ponts et chausses, Tome XX. Paris, 1849. Page 327 *et seq.*

fixing them to an arm which could be revolved at different velocities around a vertical axis. The co-efficients are given in Table III:

TABLE III.

Velocity in feet per second.	Co-efficients.		
	Observed.	Computed.	Difference.
0·950		1·622	
1·121	1·495	1·492	+0·003
1·454	1·387	1·409	—0 022
2·116	1·329	1·329	000
2·571	1·313	1·305	+0·008
2·842	1·313	1·298	+0·015
3·579	1·309	1·295	+0·014
3·732	1·285	1·295	—0·010
3·958	1·293	1·294	—0·001
6·304	1·279		
11·518	1·260		
11·966	1·264		
Sums			+0·007
Mean			+0·0009

The computed co-efficients in this table are taken from the second curve; and, as the observations were too few to group them for every half foot per second, they are given at the recorded velocities. These co-efficients decrease more beyond the curve than those of the other meters.

The co-efficients for the tachometer, hydrometric tube, &c., can be obtained in a similar manner.

The Pitot's tube, constructed by M. Darcy,* was tested by all three of the methods mentioned.

Compared with surface floats, the co-efficient was	. .	1·006
Drawn through still water,	" . .	1·034
In water of known velocity,	" . .	0·993

The second is much too large, and this discrepancy was accounted for by the fact that in these experiments the tube was placed in front of a boat which was drawn through a canal. The effect of the motion on the boat would be to raise the forward end, and thus incline the tube to the direction of motion. This would reduce the indications of the instrument a little, and thus increase the co-efficient. Other tubes, however, have had a much smaller co-efficient than this.

* Recherches Hydrauliques. Enterprises par M. H. Darcy, et continués par M. H. Bazin. Paris, 1865. Page 19.

M. Baumgarten says :* "Many persons have objected to the method of obtaining the co-efficient by drawing the meter through still water, ... and pretend that there would be a difference between this mode of observation and that of noting the number of revolutions of the meter when placed in a current of known velocity. I have undertaken a series of experiments for ascertaining whether these doubts have any foundation."

He made two series of comparisons of the meter with surface floats, in one of which the co-efficients were found to be a little larger than those obtained by drawing through still water, and in the other a little smaller; leading him to the conclusion that these two methods gave practically the same result.

The Telegraphic meters were also compared with surface floats. Table IV gives the results of the comparison of Meter No. 1 with floats in a small canal at Ogdensburg. The floats were run over a distance of 200 feet, at a depth of three feet, their time being taken by a chronometer, and the meter was placed at the same depth in the center of the distance run, as nearly as possible on the line of the passing floats.

Table IV.

No. of Obser-vations.	Velocity of Current in feet per second.			Arithmetical sum of differences of single Observation.	Mean of Differences.	Range of Differences.
	By Floats.	By Meter.	Difference.			
24	1·992	1·980	+0·012	2·314	0·096	+0·219 to —0·162
6	1·876	1·916	+0·040	0·368	0·061	+0·064 to —0·161
6	1·476	1·434	—0·042	0·443	0·074	+0·157 to —0·092

Here the difference between the mean velocities is small, while the individual floats differ greatly from the meter velocities, the float only giving the speed of the current at the moment of passing, while the meter shows the mean velocity for the time the float was running over the whole distance.

Comparisons were also made between the Propeller meter and floats, at the depth of one foot below the surface, in St. Clair river.

The mean velocity given by the 50 floats was . . .	3·619
And that given by the meter was	3·655
Difference	—0·036

* Annales des Ponts et Chausses, page 353.

There was a light up-stream wind at the time of observation, which probably retarded the floats a little.

The method of observing the floats will be explained hereafter.

Navier gives a formula for the correction of the velocity obtained by floats, assuming that the velocity of the water is uniform at the depth to which the body is immersed:

$$x = \left(\frac{2\,g\,\mathrm{M\,I}}{m\,\mathrm{S}}\right)^{\frac{1}{2}} \qquad \text{in which}$$

M = the displacement of the float,
S = the greatest immersed area,
g = the velocity due to gravity,
m = a constant, depending on the form of the float,
x = the correction required, which is always minus.

Mr. J. B. Francis found the constant m for floating rods to be 0·77 nearly.*

The double float also requires a correction, but its determination is much more difficult than the others.

In 1867 I was ordered by the Superintendent of the U. S. Survey of the North and Northwest Lakes, to make velocity measurements for the determination of the outflow of the lakes. The latest current measurements were those made by Humphreys and Abbot on the Mississippi,* and that being the largest river ever attempted to be gauged I adopted their methods of observation.

They used the double float which had been previously tried by Mr. Chas. Ellet, Jr., on the same river. Many kinds were tested, but the best was found to be an old paint-keg with the bottom knocked out, for the lower float, and for the upper a tin ellipsoid, about six by one and a half inches, bearing a small flag on a wire passing through its centre. These floats were connected by a cord from one to two tenths of an inch in diameter, and of different lengths, according to the depths at which the measurements were to be made. It was assumed that the upper float would have no affect on the lower, but would merely serve as a surface guide to show its position.

Their method of observation was as follows: "Two parallel cross sections having been sounded out 200 feet apart, a base line of the same length was laid off on the bank perpendicular to both. An observer with a theodolite was stationed at each end of the line.

* Report upon the Physics and Hydraulics of the Mississippi River, &c. Prepared by Capt. A. H. Humphreys and Lt. H. L. Abbot. 1861.

"Two skiffs were stationed in the river, one considerably above the upper and the other below the lower section line, the former being provided with several keg floats. At a signal from the engineer at the upper station, a float was placed in the river. The keg immediately sunk to the depth allowed by the cord, and the whole float moved down towards the upper line. The observer at the lower station followed its motion, keeping the cross hairs of his telescope constantly upon the flag. At the word 'mark,' uttered by his companion when the float crossed the upper line, he recorded the angle shown by his instrument, and then, setting his telescope upon the lower line, watched for the arrival of the float. In the meantime the observer at the upper station, whose theodolite supported a watch with a large seconds hand, recorded the time of transit of the float across the upper line, and followed the flag with his telescope. At the word 'mark,' given by his assistant when the flag crossed the lower line, he recorded the time and angular distance from the base line. The float was picked up by the lower boat."*

Where these observations were made the river was from 2000 to 4000 feet wide, while the base was only 200 feet. This base seems altogether too short, for the exact location of a *fixed* point is difficult when its distance is ten or more times the length of the base; but when this point is moving from two to eight feet per second, its location must be very uncertain.

It would also seem to be impossible to read and record the angles and time while a fast float was passing over so short a distance.

In the location of the soundings taken on these cross sections a base of from 400 to 1000 feet was used; and it seems strange that a shorter base was accepted for the location of the small, fast-moving float, while the boat could be held by its oars nearly stationary.

When this method was first tried on the outflow of the lakes, it was found that even in this short distance there was great difficulty in hearing the call over the wash of the waves and the ordinary noises of a large river, and also that the distance run by a fast float between the time one observer saw it passing the cross hairs of his telescope and the other heard his call was quite appreciable.

The base line was therefore increased to one-third the width of the rivers where measurements were made, and a wire from a battery run from one station to the other, having a telegraphic relay, or sounder and key, in the circuit, placed near each observer.

* Humphrey's and Abbot's Report, page 225.

Then, when a float put out from the anchored boat approached the upper section line, the observer commenced counting the beats of his chronometer, and called his assistant by a few rattles of his key. The latter turned his theodolite upon the flag, and followed it till a single touch of the key by his companion signalled its passing the upper line, when he clamped his theodolite and read the angle, the observer at the upper station recording the time of passing.

The float was signaled by the lower observer in the same manner when it passed his station.

This method apparently eliminated most of the errors of location mentioned above, but still the results were not satisfactory.

(To be continued.)

Glass Ornamentation Made Easy.—Mr. Tilghman, whose ingenious process of cutting hard substances has attracted so much attention, informs us that sand falling from a height of about thirty feet upon glass will depolish its surface, and will, in fact, cut through the flash of colored glass. This affords an easy mode of experimenting in the ornamentation of glass, partially protected by paint or other means. The specimen of engraving to which we called attention in September will shortly appear.

Horse Power of Steam Boilers.—We again call attention to that portion of the report of the Committe on the Horse Power of Steam Boilers in which they request that any engineers who have made a trial of the heating surface required to evaporate a cubic foot of water per hour, on any well known type of boiler, would send the particulars of the result to the Secretary of the Franklin Institute.

The particulars desired in connection therewith are as follows:

Description or sketch of boiler. Quantity of heating surface—fire-box and flue. The setting of the boiler. Area of grate surface. Height of chimney. Natural or artificial draught. Kind of coal. Number of pounds *consumed* per hour. Temperature of feed. Cubic feet of water evaporated per hour; and at what pressure of steam. Character of steam, wet or dry. Temperature of escaping gases. Duration of trial.

Mechanics, Physics and Chemistry.

CONTRIBUTIONS TO THE SUBJECT OF BINOCULAR VISION.

By Prof. Chas. F. Himes, Ph. D.

The stereoscope has long since ceased to be a popular novelty, and has gradually become recognized among the established aids to instruction and investigation, but its full value in either respect is scarcely yet generally fully appreciated, or by any means exhausted. Although found in almost every family there are few cases in which systematic or complete sets of stereographs upon any subject accompany it. The stereographs appear to have been purchased at haphazard, as they chanced to please a passing fancy, without any definite end in view, and in their comparative isolation from others bearing upon the same point they lose much of their value. A friend of the writer, who very early recognized the value of the stereoscope in this respect, set about making a complete collection of Parisian views, and, with Galignani's Guide in hand, made a thorough study of Paris, preparatory to a visit to that city. The leisure moments thus systematically enjoyed would have been a great source of profit even had he never carried out his original intention, but his report was that upon his arrival in Paris many prominent places in the city had a familiar appearance, that he felt quite at home, and was spared much annoyance and great waste of time, as any one who has been suddenly dumped down in a foreign city can well appreciate. The same plan was subsequently followed with reference to Rome, and other places, with equally satisfactory results. There are other fields just as open to stereoscopic study, in science, art, architecture, &c. Besides the stereographs of different places and objects, now invariably photographic, a great many of those accompanying the earliest stereoscopes, consisting of lines and dots, and colored figures, possess an interest peculiar to themselves. A systematic collection of these would illustrate the history of the development of the instrument, and of disputes concerning the theory of binocular vision, as well as of various questions in physics that have been referred to the stereoscope for solution. There is a charm in the simplicity of these stereoscopic drawings, free from all unnecessary accessories, and in the directness with which they illustrate principles, although at first sight they often appear objectless. It is proposed in these notes to give

some of the results of a series of experiments on binocular vision, some of which seem to contradict statements frequently made, because originally sent forth with the impress of high authority.

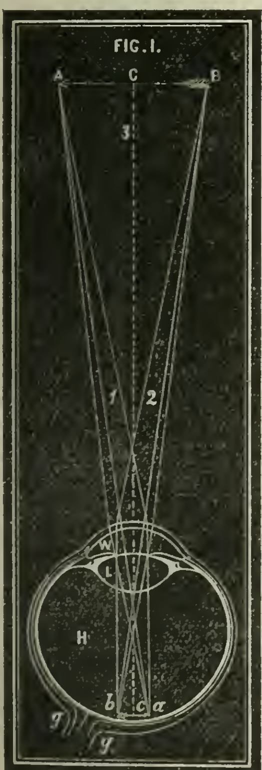
The query as to why, or how, having two eyes, each capable independently of receiving and reporting impressions of external objects, we do not get two impressions, or see double, when we employ both eyes, is a very natural one, and one that has received many explanations; but equal interest attaches to the investigation of the other nearly related question, as to the part the two eyes play, and the manner in which they operate together, to give different, and not only not confused, but clearer, and more definite perception of external objects than we can obtain with one eye. For it is an undisputed fact, that, within certain limits, say one hundred yards, they afford us an additional criterion of distance, and, through this, enable us also to perceive more readily and exactly the form or relief of objects. The usual criteria of distance independent of this, viz., the variation in apparent magnitude of known objects, number and distinctness of details in the object, number of intervening objects, vivacity of the tint, chiaro-oscuro, atmospheric perspective, geometric perspective, the effort in accommodating the eye to different distances near the limit of distinct vision, &c., enable us, by long experience, to make an estimate of distance, in most cases, with tolerable exactness, and are all equally available to one eye or both; but the estimate obtained by employment of both eyes is always most satisfactory.

The familiar statement that with but one eye open it is impossible, at arm's length, to pour wine out of a bottle into a wine glass, or to snuff a candle, &c., does not impress the mind of the person accepting it, with the utility of two eyes, as forcibly as an actual experiment. The attempt to bring the tips of two fingers together with the hands at arm's length will, perhaps, satisfy most persons, if not, a trial of the following experiment will always bring with it a pleasing surprise, even to those fully admitting and comprehending the above statements.

Let one person be seated in an erect position, with the head firmly placed against the wall or back of the chair, and let one eye be closed. Let another person take a seat in front of the first, and hold a pencil in one hand in a vertical position, within easy reach of the first person; then give the latter a pencil, and allow him to attempt to place the end of it on the end of the pencil that is held up, by holding his pencil in a vertical position, with its lower end a little higher than

the end of the pencil to be touched, and carrying it forward until he thinks it is immediately above the latter pencil, and then lowering it upon it. After it has been brought down at one time one or several inches in front, and perhaps at another time the same distance behind, and the amount of error has been readily detected, before removing the hand, by simply opening the other eye, the exactness that the new criterion, involved in the use of the two eyes, imparts to our estimate of distance will be fully appreciated. In performing the experiment it is generally advisable to hold up a newspaper, or other screen, between the parties, with one hand, with its upper edge but little lower than the top of the pencil to be touched, in order to conceal the arm and person, and eliminate any criteria of distance which might present themselves, other than that due to the use of two eyes, and which the experimenter might unconsciously employ.

Any criterion, of course, that enables us to estimate distances with so much ease and accuracy, will enable us to form very definite ideas of the forms of objects within its range, if applied to different points of the objects.



How distance is estimated, or this knowledge of a third dimensionis acquired by the use of two eyes, is, however, a matter of dispute, as well as whether it is done instinctively or by long experience.

Monocular Vision.

Before entering upon the discussion of this subject a very brief consideration of a few of the most familiar facts in connection with vision in general, besides affording a suitable introduction, and thread upon which to arrange facts subsequently, may result in economy of time.

In the representation of the human eye, Fig. 1, *gg* represents the optic nerve passing in from the brain, and expanding into a delicate, pulpy membrane, called the *retina*, upon the posterior portion of the interior of the eye ball. The other transparent refracting portions which make up the mass of the eye, viz., the *Aqueus humor*, W., the *Crystalline lens*, L., and

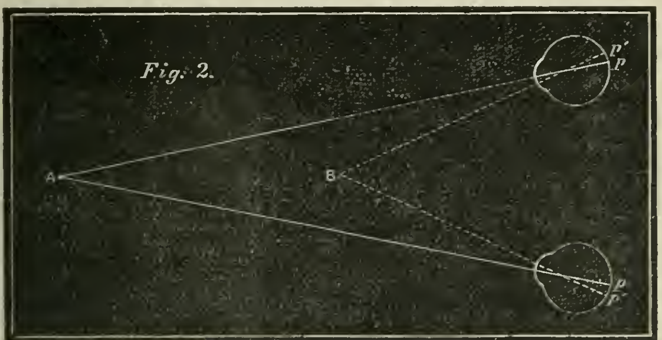
Vitreous humor, H., together equivalent to a convex lens, cause the pencils of light, emanating from the different points of an object to converge to corresponding points on the retina. Thus, those represented as diverging from A in the object are found, after entering the eye, to converge to the point *a*, those from B to *b*, from C to *c*, &c. Each point of an object would thus be found to have its representative on the retina, which together would form a perfect image of the external object. The operation can be traced no further. In some way, inexplicable to us, the optic nerve bridges over the chasm to the mind within, and over it the report of the image is made. It is, perhaps, allowable to say, that the rapid waves of imponderable ether, which constitute light, are felt by the delicate retina, just as truly as the impact of waves of the ponderable air, propagated through the beautiful accoustical combination of membrane, and bones, and liquid, is felt by the filaments of expanded auditory nerve floating in the liquid in the caverns of the ear, lying in wait as it were for indications of external objects, or just as truly as our cheeks feel the puffs of the wind and report them to us.

But whilst the effects of light cannot be traced further than the image on the retina, it has been ascertained that all portions of the retina do not report with equal distinctness, that, in fact, but a small portion, or but a spot, on the retina transmits its impression with the distinctness necessary for a clear perception of external objects, and that receding from this point,—called the *point of distinct vision* the portions of the image are reported with diminishing distinctness to the mind; therefore but one point of a body stared at can be seen distinctly, viz., that which has the rays diverging from it converged upon this point of the retina, or, since the line passing to this point through the centre of the eye, as well as the centre of the pupil, is called the *optic axis*, the fact can be stated that only that point of an object is seen distinctly which lies in the optic axis, or toward which the optic axis is directed. Thus, Fig. 1, the dotted line C *c* is the optic axis, and the point C alone would be distinctly seen. If the eye were immovable it would be necessary, in order to see the different points of an object distinctly, to turn the head, so that each point should, in turn, fall on the optic axis. But the eye has a horizontal play of 60 degrees towards the nose, and 90 degrees outward; the optic axis can, therefore, be very readily, practically instantaneously, directed upon the different points; and this is done unconsciously when an object appears to be seen distinctly at once.

This rapid, unconscious movement of the eye will be illustrated subsequently.

Binocular Vision.

But whilst with one eye an object can thus be very distinctly seen, and its *direction* also, it is evident, from the experiment previously described, that with two eyes there is a very decided advantage in forming an estimate of its distance and form, that a new, more decisive, criterion of distance is introduced. This new condition, under which the object is viewed, is the variation in the angle formed by the optic axes in observing distinctly nearer and more remote points. Thus, Fig. 2, when the point A is distinctly seen, the optic axes form

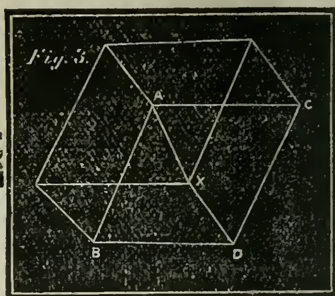


the angle p A p with each other; that the point B may be distinctly seen, the optic axes must be directed upon it, or the eyes must be rolled toward the nose until A p coincides with B p', or until the image of B occupies the point of distinct vision, p, occupied the instant before by that of A. Thus rapid, though unconscious, convergence of the optic axes upon many, if not all the points of a body, conveys to the mind the idea of distance, and reports of distance are as unconsciously translated into facts of form.

A painting or drawing may, by proper attention to perspective, shading, and other monocular criteria of distance, be made to produce quite an illusory effect, when viewed with one eye, but to both eyes it will seem flatter, and be felt to be less satisfactory. They will miss the varying binocular parallax that should accompany the varying distances represented. In proportion, however, as the other criteria of distance are faithfully introduced, this want of satisfactoriness to two eyes will be felt less, especially if range of distance lying beyond the limits of this criterion is represented.

A monocular view of an object cannot only be almost perfectly reproduced in a drawing, because perspective, shading &c., can be reproduced on a flat surface, but monocular vision for similar reasons is subject to many fallacies, by simple variation of the conditions under which an object is viewed. Thus it is frequently impossible to determine whether an object is a bas-relief or an intaglio, and it may be made to appear to be either by regulating the light falling on it. Every microscopist realizes this. In Letters on Natural Magic, by Brewster, many curious instances are given. The following interesting example is given in his treatise on the Stereoscope, p. 228, as follows:

"A very remarkable illusion, affecting the apparent position of geometrical solids, was first observed by the late Professor Neckar, of Geneva, who communicated it to me personally in 1832. 'The rhomboid A X, fig. 3,' he says, 'is drawn so that the solid angle A should be seen nearest to the spectator, and the solid angle X the farthest from him, and that the face A C B D should be the foremost, while the face X D C is behind. But in looking repeatedly at the same figure, you will perceive that at times the apparent position of the rhomboid is so changed that the solid angle X will appear the nearest, and the solid angle A the farthest, and that the face A C D B will recede behind the face X D C, which will come forward, which effect gives to the whole solid a quite contrary apparent inclination.'



Professor Neckar observed this change 'as well with one as with both eyes,' and he considered it as 'owing to an involuntary change in the adjustment of the eye for obtaining distinct vision. And that whenever the point of distinct vision on the retina was directed to the angle A, for instance, this angle, seen more distinctly than the other, was naturally supposed to be nearer and foremost, while the other angles seen indistinctly were supposed to be farther away and behind. The reverse took place when the point of distinct vision was brought to bear upon the angle X. What I have said of the solid angles (A & X) is equally true of the edges, these edges, upon which the axes of the eye, or the central hole of the retina, are directed will always appear forward; so that now it seems to me certain that this lit-

tle, at first so puzzling, phenomenon depends upon the law of distinct vision.'" There is nothing particularly remarkable in this. Every one can recall many instances in which this two-fold character of monocular diagrams caused confusion in the early struggles through Euclid. All that seems to be shown is that the mere bounding lines of an object, as they appear to one eye, cannot give us an idea of its form. There is no doubt, however, that in most cases one of the forms represented will generally present itself at first glance rather than the other, and a very plausible explanation presents itself for it. In the diagram, fig. 4, designed to illustrate another fact subsequently,

Fig. 4.

if either set of squares, (best the right hand set, because they are further apart), is observed, one of them will appear to be nearer the observer, but by very little effort it may be made to recede, and the other to advance to the front. By uniting the adjacent corners of the set by lines, the squares much more readily assume either position, especially if but one eye is employed, because a monocular drawing will be completed. But generally, at first glance, that solid will appear to be represented in which the lower square forms the nearer face, and the reason seems in this case to be, and to apply equally to that cited by Professor Neckar, that the apparent inclination, as he terms it, is more natural or usual than that of the other solid, since it appears to rest upon one of its faces whilst the other, when the lower square seems to form the remoter face, does not appear to be supported in any way, In the rhomboid drawn by Professor Neckar, this difference of naturalness of position is not so great, though it might be made still less, and it seems on that account to have most readily attracted the attention. The employment of two eyes only complicates the experiment without changing its character, as it is likely that it only succeeds, when the attention is concentrated mainly on the view obtained by one eye. The diagram is also constructed to

illustrate the difference between the evidence of one eye and of both eyes. Leaving the explanation of the part the stereoscope plays for a future time, the diagram is so constructed that, when viewed by aid of that instrument, a solid shall appear having the upper square as its nearest face, although this, as before stated, is the solid with least natural position, and this solid, fixed in form and position, can alone be made to appear; no effort of the will or imagination, no introduction of the usual criteria that affect our estimate of distance or form, can affect or change it. [In order to get the best effect it is desirable to form a *black* line diagram similar to fig. 4. This can be most readily and accurately done by placing a card, of the size of an ordinary stereograph, beneath fig. 4, and making the corners of the squares by puncturing.]

CONTRIBUTIONS TO PHYSIOGRAPHIC AND DYNAMICAL GEOLOGY, INVOLVING THE DISCUSSION OF TERRESTRIAL MAGNETISM.

By Prof. Richard Owen, M. D., LL.D.*

In offering some new facts bearing on the above subject, perhaps it is admissible previously to call to mind a few established facts, particularly astronomical, which have more or less recently been promulgated.

1. That sometimes the earth's greatest proximity to the sun occurs in our winter, sometimes in our summer; thus about 4000 B.C. perihelion was on 20th Sept.; and A. D. 1864 perihelion was 1st Jan.

2. That the sun has at present more duration of power by seven or eight days in our combined spring and summer than in our combined autumn and winter; 850,000 years since, this difference amounted to fifteen days, giving the northern hemisphere relative advantage in land forming, if the magnetic law hereafter indicated is admitted.

3. Genl. Sabine found the dip to increase with the proximity of the earth to the sun, and *vice versa;* this proximity may coincide with our winter or with our summer; at present with the former.

4. The periodical change in the form of the earth's orbit from an ellipse to a figure almost circular, must further modify the proximity chiefly dependent upon the earth's place in her orbit.

5. We must bear in mind that the ecliptic, at one period, formed

* Read before the American Association for the Advancement of Science, Indianapolis, August, 1871.

an angle with the equator at least as small as $22\frac{1}{2}^{\circ}$, the fourth part of 90°.

6. Humboldt's objection to supposing currents of electricity to move around the earth, arose from his finding that solar heat did not penetrate any very considerable depth in the soil; but he himself suggests, since the discovery made by Faraday, of warm oxygen being diamagnetic, that the electrical currents may exist in the air. It will be shown afterwards that these probably move also along earth molecules, which arranged themselves parallel to the ecliptic during the consolidation of land.

7. Fourteen years since I demonstrated, in "Key to the Geology of the Globe," published in Nashville, Tenn., that most extra tropical continents, or extra-tropical parts of continents, exhibited coast lines and mountains having a general trend of $23\frac{1}{2}^{\circ}$ east or west of the terrestrial poles; while intertropically the coast lines trend $23\frac{1}{2}^{\circ}$ north or south of the equator.

In enumerating some recently observed facts carrying out more fully the above law, after testing it by many more coincident facts than the time usually allotted would permit me to set forth in detail, I shall confine myself to the most prominent, and arrange them under

I. Terrestrial Magnetism.

Perceiving that the coast lines of continents coincided with the Terminators of some phase of the ecliptic, and other portions in the interior of the V-shaped land, were marked by other secondaries of the ecliptic, while the central, straightest and most elongated were at right angles to the equator, it seemed impossible to avoid the conclusion that the sun had a more or less remote influence in giving form to the land.

It was soon, however, further observed that the greatest heat coincided with the solstices of certain phases of the ecliptic; that all the known localities of gems (generally supposed to result from crystallization under electrical influence) could be traced along two special phases of the ecliptic, and that the secondaries of these ecliptics marked very important coast and mountain lines, great circles of heat, chemical and volcanic action, &c. Also, that under some of these had been raised, within the historical period, large tracts of country as along the Andes and in Sweden and Finland; also Islands, as Reguain, Santorin, Graham's Island, &c., while other portions not under those lines were sinking, as Greenland north of Lat. 69° N. which is north of the Terminator.

All these and many other coincidences forced the conviction that the sun, at least at the solstitial periods, must by thermal difference generate currents of electricity, probably in the oxygen of the air and in the diamagnetic earth molecules. This would at once account, as Ampère showed, for the magnetic needle arranging itself at right angles to those currents, and if magnetism can expand the earth's crust, then we see why the land was elevated along the secondaries. But if it be denied that magnetic impulses are sufficient to produce these phenomena, then we have only to consider magnetism converted into its other phase, chemical action, with the development of gases, the fusion from solidity or the solution in hot water, of metallic and earthy ingredients, the expansive power not only of the gases, but of the other phase heat, transmitted to the yet inert masses, and we certainly have, as far as human eye can penetrate, in this subterranean laboratory, all the conditions fulfilled for bringing about the effect we observe on the surface.

If, then, we admit magnetic phenomena as modifying directly or indirectly the earth's structure, we are next led to inquire what peculiar modifications are connected with the magnetic phases of Intensity, Dip and Variation. These will be briefly alluded to in the above order:

Intensity.—A great circle passing close to the coast of Brazil passes through one of the foci of intensity as laid down by Mrs. Somerville, and continued into the opposite South Pacific, passes also through, or close to, the focus of greatest intensity as laid down by Humboldt and Mrs. Somerville. If we construct an ecliptic which shall have its solstices immediately north and south of this weaker South Atlantic focus, we have an ecleptic, which especially during our winter, when perhaps that season coincided with perihelion, exhibits great intensity and electrical power, either residuary from a former period, or now existing, as indicated by the foci of its secondary, or perhaps both combined. To prove this, let us trace it through Brazil, where the emeralds and diamonds are found, next near Cape Comerin and Ceylon, the region of diamonds and sapphires, to the ruby locality between Birmah and Siam. The only other noted gem localities can be found under, or near, an ecliptic of next greatest intensity, whose solstices are found due north and south of the centre of land, centre of motion and evidently centre of the whole magnetic system. It traverses, if we follow *both* semi-annual declinations, the

diamond regions of Brazil, South Africa and of India, and embraces between its converging lines the diamond region of Borneo.

The secondaries for the solstices of maximum intensity arise respectively from nodes on the equator just east of Africa and north-east of the Marquesas. The former, which are the stronger, define the north-east coast of Africa along the Red Sea, through Hungary and Prussia to Iceland and Greenland, where its east coast intersects the arctic circle. This is exactly 90° from both the nodes just spoken of, for which reason, and because it is antipodal to Sir J. Ross' Mag. S. Pole, but more especially because all the seventy-four observations for declination laid down around the globe (as given in Lard. Nat. Phil., p. 208,) converge in their variation to this point, except a few drawn aside by the magnetic pole of dip, we must consider the Greenland Arctic Pole as the pole of greatest intensity. This terminator further passes through the Hudson Bay focus of intensity, while its mate passes through the Siberian focus. Intensity thus appears due to combined proximity of the sun and greatest solstitial power.

Dip.—If we trace the equator of dip according to the best authorities, it is found to undulate between the two ecliptics just described. and to intersect them where they intersect each other, vertically in the Western Hemisphere, under Sir J. Ross' North Pole of dip, in the Eastern Hemisphere due south of the Gulf of Obi, in which, about lat. 70 N., there seems, as was suggested by Hansteen, to be an Asiatic North Pole of dip, and, I may add, perhaps also an Asiatic North Pole of intensity on the arctic circle 180° from Greenland. These have probably South Poles ; indeed the antipode of the Gulf of Obi is laid down in Humboldt as a point indicated by Ross as having magnetic importance (see Vol. IV Cosmos, Longman's, Edit. p. 97). Dip, then, seems that phase of magnetism connected with equilibrium, between the ecliptics of intensity, perhaps between perihelion in our winter and perihelion in our summer.

Variation or Declination.—The whole magnetic system is known to move slowly and periodically ; at present that movement is from west to east in the northern hemisphere, while in the southern the motion is from east to west.

If we consider the African node, where the centre of motion, centre of dip, and centre of land and solstitial meridian of intensity No. 2 all intersect, as the centre, also, of magnetic oscillation, and permit the secondaries to vibrate to their supposed extremes, viz. 16½° each side of the terrestrial North Pole, we find the western secondary

following important coast lines, and not only passing through the Greenland pole of intensity, but through the Boothia Felix pole of dip and the South Pole of intensity. Trace now the eastern secondary and we find it marking the Gulf of Obi pole and its antipodes, besides slightly deflecting the northern part of the Ural Mountains, which in the rest of their course conform to an equinoctial secondary; being directly over the east African node of ecliptic intensity No. 1. The variations for Paris, taken from A. D. 1580 to 1835, as given by Lardner, p. 210, are measurably accounted for on the supposition of this oscillation occupying perhaps 300 years or thereby, while the intensity vibrates or changes from the one secondary to the other, in accordance with the predominance of electricity in one ecliptic or the other; the dip, however, varying also in connection with perihelion and aphelion.

Horary and Semi-annual Variations in Declination.—If strong additional evidence were required to show that the sun's electricity caused the position of the needle, it is found in the two facts: 1, that the needle every day has a slight variation from soon after average sunrise to soon after his reaching the meridian of any given locality; the currents evidently approaching the needle in a somewhat different plane, as modified by refraction or other causes, from the plane assumed at noon; and that there should be slight reaction in the afternoon, when the warmer molecules are *west* of the colder instead of being east of them, seems natural. 2. The second is that the needle besides varies six months in one direction and, changing at the equinoxes, exhibits its variations for six months in the other direction; that the semi-annual variations in declination should be different in the northern and southern hemisphere and change at the equinoxes, is readily understood; but why St. Helena, in about 15° S. lat., and Singapore, about 2° north of the equator, should partake half the year of the perturbations peculiar to the northern hemisphere, and during the other six months of perturbations peculiar to the southern hemisphere, was not comprehended; it is, however, at once explained when we observe that the former place is situated on the intensity ecliptic No. 1—the other on intensity ecliptic No. 2.

Disturbance Variation.—As there is a residuary power in the paramagnetic molecules (which in the Rocky Mountains prevents the use of the magnetic needle, and compels the employment of Burt's solar compass) and as the direction of magnetic impulses would be north north-west in the Rocky Mountains, while in the Appalachians, or even

at Toronto, it would be north north-east, although both sets of impulses start from near Chimborazo, it is easily seen why, as Point Barrow is near one secondary and Toronto near the diverging secondary of the other solstice, the so-called disturbance variation, although occurring simultaneously, should yet have opposite phases.

Agonic Lines.—There is no variation at all points centrally between these diverging secondaries, namely: along the secondaries of the equator; the needle, setting itself at right angles to the equinoctial plane, points to the terrestrial north and south pole. These agonic lines occur chiefly at the meridians of the ecliptic nodes, but are found more or less every 45° east and west of the west African node, which may be termed the prime magnetic meridian.

II. Geology and Physical Geography.—The facts, recently observed, bearing on this second sub-division of the subject are chiefly these:

Along the ecliptics prevail mostly those chemical effects such as the crystallization of carbon into diamonds, &c., as well as regions of greatest heat, and the upheaval of the second highest mountains; while along the secondaries we find abundant evidence also of heat at the geysers, linear hot springs, linear volcanoes, Gulf and Japan streams, &c., as well as chemical action in erupted molten rocks, liquid mud, gases and the like; and also mark the rise of the Himalayas.

The divergence of two terminators south-west of South America seems the probable cause why the tidal wave, instead of entirely following the moon, here separates. The heat of the Scandinavian terminator may account for the melting of the icebergs and the dispersion of drift from that region, and the activity of the geysers in Iceland; while a secondary of the other ecliptic has given warmth to the region of the Lena.

Vital energy seems to have been imparted to vegetable and animal life by the magnetic impulses, chiefly of these solstitial secondaries, as near them we find the giant Sequoias, the ancient monsters of Nebraska, of the Pampas Plains, of Siberia and the Urals.

The land on the globe is to the water as 66 or 67 to 180 (the former without the Antarctic continent), and in accumulating in the northern hemisphere (probably because proximity agreed with our winter intensity when paleozoic land was forming during the prevalence of intensity ecliptic No. 1), it has extended itself chiefly from the Tropic of Cancer to the Arctic region. Africa forms an excep-

tion, for that continent has accumulated as land around the central intersection of the terrestrial and dip equator in such manner that the Mediterranean is nearly 33° north of the node, and the Cape of Good Hope is a somewhat greater distance south, together 66° or $66\frac{1}{2}$°, while the width of Africa, from Cape Verde to Cape Gardafui, is also 66°. The length of North America and of South America, as well as of Asia, from her northern Shore to Cape Comerin, also measures 66°; indeed the length and breadth of all land is found to be some dividend of that number.

Sixty-six and a half degrees being the complement of the ecliptical angle, or, in other words, this being the angle which the earth's axis forms with the plane of the equator, the land would naturally assume those dimensions, as well as the rhomboidal shape which several continents have, with the acuter angles pointing north and south, if the sun caused its development. As an interesting corroboration of this law, that the sun gives form and dimensions to the land, let us take with compasses the distance from Cape Comerin (where the greater intensity ecliptic is found) to the north coast of Asia, and moving one foot of the compasses thus extended along the north coast, either east or west, the other foot will be found to correspond to one or other ecliptic. This appears to indicate that the magnetic effect is powerful about $66\frac{1}{2}$° north of the electrical current, inducing strong terrestrial magnetism at that distance, although the poles are 90° from the equator, measuring on the secondaries.

The chief deposits of the paramagnetic metals, especially when nearly or quite pure, connect north and south, while those of some diamagnetic metals, gold at least, can be traced along parallels of latitude. Time has not permitted a full investigation of this practically useful branch; but I may mention that, while the chief deposits of coal are found along or parallel to the solstitial secondaries, those of petroleum and bitumen are near those (and perhaps across one, as in Pennsylvania), but are connected by lines which are secondaries to the equinoctial plane, such as the great circle passing from New York and Pennsylvania through Virginia and North Carolina, Cuba and Jamaica, New Granada, Burmah, Lake Baikal, &c. Trinidad, however, is nearly under an ecliptic, and the Baltic, where amber is common, under one of its secondaries. The Caspian Sea bitumen is under an equinoctial secondary.

We must now, reserving further details for future discussion, hasten to the

SUMMARY.

A vast number of coincidences are fully explained, if we admit the law that solar influence indirectly has caused the phenomena to which Humboldt in his immortal Cosmos gave the name "Reaction of the interior of the earth on its exterior." Add to this the fact that the whole is strictly in accordance with the correlation of forces, and throws much light on the hitherto unexplained phases of Terrestrial Magnetism.

Much, then, as theorizing is sometimes to be reprehended, and generalization without sufficient facts is to be condemned, probably every scientific man will agree that (as here no favorite theory was started with, to which some facts were made to bend while anomalies were set aside, but facts were collated until they pointed to a law) we are justified in following up this interesting glimpse into the arcana of nature, and in admitting as a general law that which embraces the whole array of coincident facts, beautifully explaining many phenomena, and pointing us to the conclusion which every year, as science advances, is more powerfully set forth to our observing and reflecting faculties, that there is uniformity and simplicity in the great plan of creation.

If the law is admitted, it would bring us to something like the subjoined conclusions:

1. The sun is the source of the modifications on the earth giving the form and dimensions of the land; operating through some of the phases, or modes, of motion, which we embrace under the names light, heat, electricity, magnetism, vital force, and probably nervous energy.

2. By thermal difference, ecliptical and equatorial currents are generated chiefly from east to west, from the hotter air and earth molecules to the cooler, each afternoon, however, producing a slight reaction, on the same principle.

3. These currents generate magnetism at right angles to themselves, viz., along the secondaries of the ecliptic in all its phases, although most strongly at those of the solstices, and also along the secondaries of the equator, which are meridians, especially at every 45° apart, beginning east and west, from the prime magnetic meridian.

4. The electricity of the ecliptics has produced heat and crystallization, and offers an explanation of the Zodiacal Light; while the magnetism of these secondaries, either directly or by conversion into chemical force, has developed the land, called forth the metals, stirred the volcanoes into activity, heated the Geysers, the ocean currents

and the hot springs, modified the climate at different meridians on the same parallels, caused the tidal wave to diverge, perhaps melted the glacier ice that held the Drift boulders, accounts for the Aurora-borealis and australis, stimulated vegetation, and gave energy to animal life.

A field is thus opened for further investigation, which pertains not to the Geological and Mining Engineer alone, however important to them, but offers labor full of interest for the Astronomer, in defining accurately the modifying periods of greatest heat, light, electricity, magnetism, &c., in connection with the precession of the equinoxes, proximity of the sun, solar spots, form of the earth's orbit, &c.; for the Physicist, in confirming and classifying the observations connected with terrestrial magnetism; for the Physical Geographer, in tracing his orology, courses of rivers, winds, currents, electrical and scismographic phenomena, also the distribution of plants and animals, as well as the distribution of heat and rain, pursuing these researches with hereby increased light and vigor; while to the Naturalist, the Anthropologist and Historian, or Student of the Philosophy of History, there is furnished ample food for reflection.

Finally, above all, these sublime developments should stimulate us all with fresh desire to understand more fully the beautiful and immutable laws by which the Divine Ruler holds the universe in harmonious action, and should cause us to increase our endeavors ever to live in accordance with those divine laws.

SIGNAL SERVICE WEATHER REPORTS.

By Pliny Earle Chase,
Professor of Physics in Haverford College.

The recent instructive articles upon the Signal Service Bureau, in Scribner's and Harper's Magazines and the "American Journal of Science," have by no means exhausted the interest which attaches to the weather bulletins. Without much trespass on the ground which others have so well covered, I will endeavor to present to the readers of the *Journal* some details which I hope will prove acceptable, for a large portion of which I am indebted to the courtesy of Prof. Cleveland Abbe, the accomplished astronomer and meteorologist, to whose skill we owe the successful daily forecasts.

Dr. Franklin's demonstration of the identity of atmospheric and

frictional electricity, and his discovery of the customary travel of storms toward the northeast, the distribution of instruments and instructions to observers by the Franklin Institute, Dr. Emerson's observation that a great rise of the barometer often belies its stereotyped prediction of "Set Fair" by preluding a northeasterly storm, the invaluable generalizations of Redfield and Espy, Ferrell's exhaustive mathematical analysis of "the motions of fluids and solids on the surface of the earth," Blodget's Climatology of the United States, Loomis's treatise on Meteorology, Coffin's Winds of the Northern Hemisphere and his tabulation of the observations of the indefatigable corps organized by the venerable Secretary of the Smithsonian Institution, Professor Henry's various physical, and especially his electrical, thermal and hyetal researches, Bache's Girard College Observations and Schott's discussion of the magnetic results, are but a portion of the contributions of American students to what might almost be regarded as the American Science of Meteorology.

Foreign meteorologists have not been backward in recognizing and acknowledging their indebtedness to American researches and suggestions, and few of them are so sanguine as to hope for a long maintenance of the accidental precedence, in successful applications of weather telegraphy, which they gained in consequence of the interruption of most branches of scientific labor by our civil war. Our territory, stretching across an entire continent in the normal pathway of storms,—the extensive plains of the Mississippi and Missouri valleys, furnishing peculiar opportunities for the blending of polar and equatorial currents,—our popular government, untrammeled by the exhausting exactions of monarchical power and huge standing armies, and therefore better able to grant the appropriations which are requisite for the support of an efficient corps of observers,—and the happy thought of military organization and responsibility, which Gen. Albert J. Myer, the chief signal officer, has so successfully carried out,—are advantages which may reasonably make us hopeful of tracking the wind, which "bloweth where it listeth," with unprecedented, if not with incredible success.

The hours appointed for the regular observations at each of the fifty-six subordinate stations are $7^h\ 35^m$ A. M., $4^h\ 35^m$ P. M., and $11^h\ 35^m$ P. M., Washington mean time. These hours were fixed upon because there were no others which would divide the day into three so nearly equal portions, and at the same time find the telegraph so free from other business. A system of circuits is specially arranged for

the office: 1, from Washington to New Orleans; 2, from Washington to New York; 3, from Washington to Chicago and San Francisco; 4, from Washington to Lake City; and all the subordinate circuits run into one of these four main stems. The whole line of wires of the Western Union Co., and of the Franklin, in case of the failure of the Western Union, is at the disposal of the Signal Office at the hours above stated. Each observer has an exact minute for starting his observations to Washington, sending them through such cities as desire to receive the report, Key West, for example, sending its despatches through Mobile, New Orleans, etc. These arrangements are made with a view to the greatest possible economy, and the charges are far below the ordinary rates for telegraphing. Montreal and a system of circuits from Canada have lately been added to the list of communicating offices, the legislature of the Dominion having voted the necessary appropriations.

The regular dispatch from each station consists of four lines of cipher, with five figures in each line. These figures are appropriated as follows:

Line 1.—Height of barometer, 3 figures; number of station, 2 figures.

Line 2.—Height of thermometer, 2 figures; relative humidity, 2 figures; direction of wind, 1 figure.

Line 3.—Velocity of wind, 2 figures; date, 2 figures; state of weather, 1 figure.

Line 4.—Upper clouds, 1 figure; lower clouds, 1 figure; rain fall, 3 figures.

The economy and simplicity of this arrangement may be readily shown by a single example:

0	1	2	5	6
6	2	7	7	8
0	2	1	4	1
2	0	0	0	0

The "Key" furnishes the following interpretation: "Barometer, 30·12 inches; Station, 56 = Montreal; Thermometer, 62°; Relative Humidity, 77 per cent.; Wind, 8 = N. W.; Velocity of wind, 2 miles per hour; Date, August 14; Weather, 1 = Fair; Sky, 2 eighths covered with cirrus clouds; Lower clouds, 0; No rain since last report."

The messages are sent in unbroken succession from the consecutive stations, the operator noting upon each sheet of figures the time when it was received. The division of the columns into four-line groups is made in the office, and the items are transferred, 1, to the manifold bulletin; 2, to the bed-plate for printing the daily maps; 3, to the map for official study, on which the isobaric lines (lines of equal barometric pressure) are drawn, and any notes or remarks are written which may facilitate forecasts.

In addition to the observations for telegraphic transmission, others are taken at the customary local hours, 7 A. M., and 2 and 9 P. M. These are entered on "Form 4" of the printed blanks, under the following heads: "Date of observation; Time of observation; Height of barometer; Height of attached thermometer; Height of exposed thermometer; Reduced barometer; Hygrometer (open air), Dry bulb, Wet bulb; Relative humidity; Direction of wind; Velocity of wind in miles per hour; Daily velocity of wind; Pressure of wind, lbs. per square foot; Amount of cloud; Direction in which upper clouds move; Rain (or snow) commenced (Time); Rain (or snow) ended (Time); Amount of rain or melted snow; Remarks." The sheets containing these entries are forwarded weekly, by mail, to Washington, together with copies of the daily telegrams as checks on the telegraphic reports.

When the returns from about half the stations have been received Prof. Abbe and his assistants commence a detailed synopsis, noting especially the changes in the barometer and thermometer, whether stationary, rising or falling, the direction of the wind, state of the weather and moisture of the atmosphere. From this synopsis the estimate of probabilities is made and a decision is formed as to the proper signals to be displayed, on the lake shores and the Atlantic and Gulf coasts, for the benefit of commerce. Press reports are also prepared, dated 10 A. M., 7. P. M. and 1 A. M., which are at once given to the agents of the Associated Press, and telegraphed by them to all their correspondents. The Bureau forwards the reports, at its own expense, to a few points which are not reached by the Associated Press.

In making the estimates it is necessary to bear continually in mind the general principles of pneumatics and hydrodynamics, and especially the laws developed in Ferrel's treatise, to which I have already referred. The following rule is of great service: "Stand with your left hand toward the place where the barometrical reading is lowest,

and your right hand toward that where it is highest, and you will have your back to the direction of the wind which will blow during the day." This is generally known as Buys Ballot's law, having been empirically deduced by Prof. Buys Ballot, of Utrecht, apparently without knowing that he had been anticipated by the purely theoretical reasoning of Ferrel. Capt Toynbee, of the British Meteorological Office, proposes to substitute for the places of highest and lowest barometer those where there has been the greatest rise and fall during the previous day, in order to judge of the direction toward which the wind is tending, and his modification often furnishes results of considerable value.

Since storms are the culminations of atmospheric disturbance, it is natural to look for them where such disturbance is greatest, either on the borders of the greatest barometric elevation, or at the centres of greatest depression. In estimating differences of pressure, and consequent wind producing force, "barometric gradients" are used which are customarily expressed in hundredths of an inch of mercury per fifty geographical miles. For example, if the barometer at Philadelphia stands at 30, while the one at Fortress Monroe stands at 29·50 inches, the distance being about 200, or 4×50 geographical miles, the gradient is $50 \div 4$, or 12·5. The best meteorological manuals give a variety of empirical rules, which have been deduced by Prof. Dove and others, for interpreting the indications of the barometer under various conditions of temperature, moisture, wind and season, which add greatly to its value as a guide for forecasts.

The temperature is invariably elevated upon one side of an area of low or high pressure and depressed on the other, and it is generally warmer in advance of any storm centre and colder in the rear. In forming estimates, if due regard is paid to the elevation, latitude and physical surroundings of the station, the thermometric indications of rising and falling temperature are valuable auxiliaries.

The humidity is large in advance of storm centres, and small in their rear. Increasing humidity is, therefore, an intimation of an approaching storm; decreasing humidity, of clearing-up weather. The more moist the air the greater will be the effect of a general diminution of pressure or temperature in inducing rain.

A "backing" wind is a well known sign of unsettled weather; a "veering" wind, or one which shifts with the sun, is an indication of fair weather. Within areas of high pressure the winds blow from the centre; in areas of low pressure, towards the centre; in either

case they are deflected towards the right hand as they move forward. Backing currents, or currents which, in the northern hemisphere, move in a direction opposite to that of the hands of a watch, are called cyclones, or cyclonic; veering currents are termed anticyclones, or anticyclonic. The backing or veering of the currents should not, however, be confounded with the shifting of the wind, which is determined by the directions in which the centre of the area of disturbed pressure lies and is moving. Hurricanes, the Chinese "great-winds" or typhoons, and the most sudden and violent storms, are cyclonic. It is often said that all storms are cyclonic, and even that all winds have a cyclonic origin, both of which statements are incorrect. The prevailing currents in the United States are anti-cyclonic, those in Western Europe cyclonic. Anti-cyclonic storms occur on both continents, but more often in America than in Europe. One of the surest indications of the approach of a storm to our southern and south-eastern coasts is the cyclonism of the winds in that region. Cyclones, in our hemisphere, tend to move northward, anti-cyclones southward.

The clouds, by their forms, changes and motions, indicate the relative temperature, moisture, pressure and direction of upper currents. The dependence of rain upon the meeting and blending of warm and moist with cooler bodies of air, is shown by the prevalence of two layers of cloud in stormy regions, the upper stretching far in advance of the lower, but descending and joining it in the rear of the area over which rain is falling. The "stratus" or "layer" clouds are generally reported in connection with threatening weather at the different stations, and the higher and more fleecy—"cirro-stratus"—usually precede the storm clouds at some distance.

The general movement of the areas of stormy and clear weather, high and low pressure, warm and cold temperature, moist and dry air, is eastward, over the larger portion of our territory, with velocities ranging from one to fifty, and probably averaging less than thirty miles per hour. This movement, which is controlled by the flow of the upper atmosphere, and is most uniform in winter, greatly facilitates predictions of the progress of storms from the Rocky Mountains to the Atlantic seaboard, and a careful observation of the areas of greatest humidity most favorable to rapid condensation will suggest probable sinuosities in their track. The more violent winds generally follow in the rear of the area of lowest pressure, but those

which precede that area may often be more dangerous, on account of the accompanying rain, snow, mist or fog.

As a typical illustration of the ease with which our ordinary winter storms can be traced, Prof. Maury refers to the reports of February last. On Feb. 21st, in the midnight report, the commencement of a storm was announced at San Francisco. Its progress was followed from bulletin to bulletin, until it reached the Atlantic coast. On the 23d, at 4h. 35m. P. M., the announcement was made: "it is probable that the storm predicted for to-day will soon reach Lake Michigan, where clouds and brisk winds now prevail." It made its appearance on the lake on the morning of the 24th, when the office again successfully predicted that it would "move north-eastward, with comparatively little rain or snow except in Canada, and southerly winds with rain from Cape Hatteras to Maine."

One of the most important hydrodynamic principles is the tendency towards equilibrium. The alternations of solar heat and nocturnal radiation, modified by the different capacities of mountains, forests, deserts, lakes and oceans for absorbing and retaining warmth and moisture, are continually disturbing the atmospheric equilibrium, and the problem of the weather-seer is to judge, from the actual conditions at any moment, what must take place to restore the normal condition of a given place or region, for a given day or season. For this purpose, tables and charts, constructed from the averages of long series of observations, such as are given in Coffin's "Winds of the Northern Hemisphere," and in Buchan's article on the mean pressure of the atmosphere (Edinburg Transactions, vol. xxv. Art. xvii), are of great service. Buchan's diagrams of monthly isobaric lines, although based upon comparatively meagre observations, are the best guide yet published to the equilibrating forces which are constantly struggling against the disturbances. The signal office is collecting an immense amount of observations, with the view of preparing similar charts specially fitted for American use, and it is also investigating various laws of local disturbance, which will eventually be published, so as to be practically available.

There has been a very general impression that it would be much more difficult to anticipate the storms in summer than in winter. There is undoubtedly a greater variety of disturbances during hot weather, and it is impossible to track the commotions which come to us from the Atlantic, for so great a distance as those from the Pacific. But difficulty is always a stimulus to ingenuity, and the degree of

success, which has attended the summer work of the office has been most gratifying.

From the 2d to the 4th of June a storm passed from Key West through the centre of the Gulf of Mexico, the daily bulletins signalling its progress. The cyclonic winds in the Gulf States gave notice of its approach, and the office accordingly issued the warning on the morning of the 2d, "it is probable that the high winds in the Gulf will advance with rain to the coast of Louisiana." A heavy storm swept with great damage over Louisiana and Galveston, from the morning of June 3d, to the evening of June 4th. The approach of a damaging storm, heralded by similar indications, to the coasts of Florida, Georgia and South Carolina, was shown by the bulletin of 1 A. M. on Aug. 16th, and its progress duly reported for the four following days, until it had "moved north eastward, beyond the cognizance of our stations."

One of the most important generalizations which may be regarded as almost conclusively established, is the fact that the summer storms and tornadoes appear simultaneously over well defined regions of falling or low barometer, and never over districts of rising or higher barometer. Several cases have occurred of areas of low barometer advancing from San Francisco with pleasant weather, and producing a storm upon arrival at the lakes.

The disturbances in the upper atmosphere more frequently pervade the whole mass in winter than in summer, producing wide-spread storms. Similar disturbances, when the thin lower stratum of heated air at the earth's surface presents the proper conditious of penetrability, may produce numerous local storm-eddies in summer, in the subjacent area which would have been involved in a general storm if it had been winter. In winter, areas of low barometer stretch out towards the lakes oftener than in any other direction, a fact which is generally attributed to the moisture of the air over the lakes. Prof. Abbe thinks that precipitation, which is oftener shown in the form of cloud than in the form of rain, accounts for the phenomenon more satisfactorily than the mere presence of moisture. The greater persistence of low pressure in the lake region than elsewhere during summer, is perhaps more especially attributable to the solar heat which produces, at that season, a normal region of low barometer in the British Provinces, similar to the one in the interior of Asia. In each of those districts there is normal high barometer during winter.

There are, on the other hand, some districts in which the persistence of high barometer during summer is very striking. They are, perhaps, more frequent in the neighborhood and west of mountain ranges, in Western Pennsylvania for example, as if the air, in its eastward flow, were compressed by the resistance it encountered in traversing the ridge. From the 15th to the 18th of July last, the barometer had been steadily ascending from Western Virginia to Massachusetts. On the 18th, the dense air suddenly poured over the mountains, driving a small but severe storm on to the coasts of New Jersey. This storm was wholly exceptional in the experience of the office, and it therefore came without any official warning.

The haziness of summer and autumn, especially of "Indian summer," have often been attributed to burning prairies, but many have been skeptical as to the possibility of a local fire kindling so "great a matter." During the past few weeks the observers have been able partially to remove this doubt. From the 12th of August, the bulletins, for several days in succession, announced a dense smoke at Detroit, sufficient to impede navigation on Lake Huron. Much of it came from burning woods in upper Michigan, some of it from the woods east of Lake Huron. The smell and haze gradually spread south-eastward as far as Maryland, furnishing indications of the direction of the upper atmospheric currents, and operators at Oswego and other stations eastward or north-eastward, also reported "dense smoke" or haze.

Eager Olivers, "asking for more," already solicit predictions for two or more days in advance. If the forecasts for a single day were infallible, they might be used as the basis for new ones; and so on indefinitely. But if the first forecasts prove true in only three cases out of four, those based upon them would be probably correct in only nine cases out of sixteen, which is little better than a random guess. Still we may hope that the tabulations and discussions in which the office is now engaged, the Smithsonian investigations of annual and secular rainfall which are now in press, and the study of meteorological records by groupings in lunar and planetary periods, will ere long warrant bolder undertakings. Until some safe basis for more extended forecasts has been found and tested, let us be thankfully content with our present daily announcement of "probabilities," which, even if it does not fully satisfy the most sanguine longings, is far beyond anything that could have been reasonably anticipated from so brief and limited experience.

Use of Bromine in place of Chlorine in Analysis.*—It will be of interest to those engaged in the laboratory, to know that the substitution of bromine water for chlorine is highly recommended by H. Kämmerer; who, after using the process, claims for it several advantages.

The use of chlorine in the precipitation of manganese, the detection of nickel with cobalt, in the separation of arsenic, &c., is attended with a great inconvenience from the extreme decomposibility of the reagent and the frequent unpleasant necessity of preparing it anew; while bromine is free from this objection, inasmuch as it can be prepared in a few minutes whenever needed.

The author informs us that in all cases where the use of the reagent depends on the formation of a hypobromite, the action is far more energetic than with chlorine.

The detection of nickel in presence of cobalt, in cyanide of potassium solution, by the process of Liebig, often fails when old or weak chlorine is used; while on the other hand, the author assures us bromine never fails of success.

Bibliographical Notices.

The Claims of the Academy of Natural Sciences of Philadelphia to Popular Favor. By W. S. W. Ruschenberger.

This pamphlet, from the pen of the Academy's President, contains, besides a running history of this honored Society, a strong statement of its urgent wants, and an appeal to the intelligent public, who are indebted to it for so many days of interest and instruction, for aid in placing the Institution in a position where its activity and usefulness will not be trammelled for want of means.

It should be a matter of pride to our citizens to place the magnificent and, in certain departments, unsurpassed collections of the Academy in a building where they would be safe from the possibility of destruction by fire, and it is certainly a matter of regret to us that good cause should have existed to have made the publication of the pamphlet necessary.

* Ber. d. Deutch. Chem. Gessel. iv. 218.

Four Years at Yale. By a Graduate of '69. C. C. Chatfield & Co. New Haven, 1871.

A detailed account of the origin, the history, the students—their life, customs, politics, traditions,—and, in short, of everything pertaining to this, the most peculiar of American colleges, is here presented in a most spirited and entertaining manner; and the interest which its abundant fund of narrative affords, can be appreciated only upon perusal, to which we most heartily recommend it, to all who have past experience, present enjoyment, or future anticipation of college life before them.

The only portion of the book which is open to unfavorable criticism is that in which the author, emerging from the character of narrator, which he sustains most ably, presents his views upon the "New Education" and its advocates, in language characterized more by that good old-fashioned prejudice—for which his *alma mater* may not be altogether blameless—than for sound reasoning.

Franklin Institute.

Proceedings of the Stated Meeting, May 17*th*, 1871.

The meeting came to order at the usual hour, with the President, Mr. Coleman Sellers, in the Chair.

The minutes of last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their Stated Meeting, held May 10th, donations to the library were received from

The Royal Astronomical Society, the Statistical Society, the Society of Arts, London. The Austrian Society of Civil Engineers and Architects. The Manchester Steam Users' Association, Manchester, England, and Les Mondes, Paris.

Hon. Wm. D. Kelly, House of Representatives, Washington.

Com. B. F. Sands, U. S. Naval Observatory.

The Committee appointed to examine into the method of Estimating Horse Power of Boilers and Engines reported progress, and were continued.

The Secretary's Report on Novelties in Science and the Mechanic Arts was read; upon which the meeting adjourned.

WILLIAM H. WAHL,
Secretary.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXII.] NOVEMBER, 1871. No. 5

EDITORIAL.

ITEMS AND NOVELTIES.

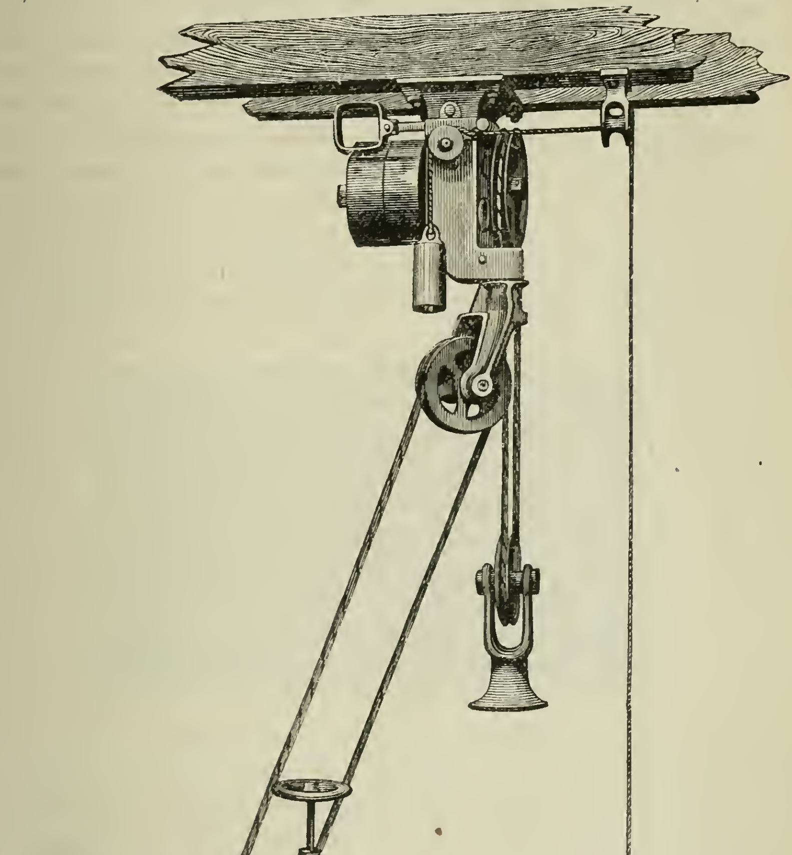
Portable Drilling Machines.—It is becoming an acknowledged principle in machine-shop practice that, where a machine tool, intended to operate upon a piece of work, is lighter and more easily handled than the work, it is cheaper to move the tool to the work than the work to the tool. The great difficulty has been to put this principle into practice. Until within late years, machinery has been designed so that the framing and heavy parts were made up in sections and bolted together, thereby greatly multiplying the surfaces and joints to be fitted, increasing the amount of work necessary, and rendering more difficult the attainment of accuracy and the consequent successful working and durability of the machinery. This plan was adopted, not from preference, but from the difficulty of handling heavy pieces, and the want of tools adapted to heavy work. At present, we find engineers making their designs so as to throw as much of the work as possible on to the foundry, and as little as possible to the machine-shop. Heavy castings and few joints are cheaper in construction, more accurate when done, and more durable in use.

One great difficulty is found to be drilling the holes for bolts, &c., in large and heavy iron work. This has always been a great source of delay and expense in machine construction. The Radial Drill was designed to overcome this, and proved a useful and excellent tool: but, being stationary, was often found to save but little over the expense of hand-drilling, on account of the time required to move heavy beds, &c., to it, merely to have a few holes drilled in them. Besides, the first cost of a stationary Radial Drill of any capacity is such as to preclude their use by any but large and wealthy establishments.

Messrs. Thorne & De Haven (Twenty-third and Cherry streets, Philadelphia) are building *Portable* Radial Drilling Machines, which have all the advantages of Radial Drills, and at the same time can be bolted to heavy parts of machinery or iron work, with much greater facility than a ratchet-brace can be rigged up for hand-drilling, and can be driven by power in any position, no matter where the work may be. They are adapted to drilling holes in all pieces of machinery which are inconvenient to move, or which cannot be readily adjusted under stationary drilling machines. They afford a great saving of time where several holes are to be drilled in the same piece, even where a drill-press could be used, in consequence of the ease and accuracy of adjustment gained by the screw and worm movements of the radial arm carrying the gearing and drill-spindle. They are specially needed in marine, locomotive and all erecting-shops, and in yards adjoining shops, on columns, architectural work, water-mains, gas-works, iron ships, iron bridges, &c.

The accompanying cut is a true representation of Messrs. Thorne & De Haven's smallest size machine, which, with the assistance of the following description, can be easily understood.

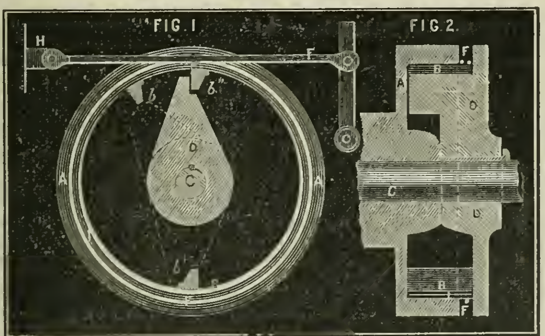
The counter-hanger is stationary, receiving power from the line-shaft of the shop through a flat belt on "fast-and-loose" pulleys, in the usual way. The power is transmitted to the drilling machine, in any direction and to any distance, by means of a round belt passing over "idler" pulleys, held in a frame, which rotates on a hollow stud, through which the pulling side of the belt passes. A weighted "idler" pulley hangs on the "slack" side of the belt, and maintains the tension, permitting the distance of the drilling machine to be varied at will. When the rise and fall of the weighted "idler" does not give sufficient variation of distance, additional lengths of belt can be inserted by means of the hook couplings used, and any distance thus obtained. The drilling-machine itself is a complete Radial Drill.



PORTABLE DRILLING MACHINE.

The height of its post can be varied to suit different lengths of drills and chucks; the radial arm is travelled by a screw and rotated by a worm and tangent wheel; the cone pulley has four steps for four speeds; the drill spindle can be set to an angle with the base in any direction. The base of the machine can be bolted to the work, either vertically, horizontally, or in any plane. It can be used to drill parallel with its own base, by holding the post in the clamp-bearing on side of base.

Spring Coupling.‡—The accompanying figures represent a form of spring coupling recently patented in France and England. A, is



the pulley to be driven; C, the driving shaft, the latter carrying a driving arm, D. The outer end of this arm presses against a stop b″, fixed to the interior of the spring B, which is surrounded by leather or other packing, I. The spring B tends to expand and force the surrounding packing into contact with the part of the pulley A within which it is placed, thus driving the pulley by frictional contact. When it is desired to stop the pulley, various arrangements may be used for compressing the spring and destroying contact. In the figure here given, the tightening of the cord F produces the desired result. If the pulley A is made the driver, the device which compresses the spring and disengages it from the pulley, will also serve to act as a brake to arrest the motion of the shaft C. The minimum grip of the stop occurs when it is in the position b; it will be greater at b′, and will reach a maximum when placed at b″.

J. H. C.

‡ Engineering, 1871, 361.

A Huge Chimney.*—To obviate the annoyance caused the inhabitants by the contamination of the air, from the fumes of neighboring cement kilns at Dover Court, England, the proprietor is having a gigantic shaft constructed. The structure is remarkably well built, formed of the hardest red bricks and the best cement of the district. Its height when finished will be upwards of 190 feet. It is square built, and 20 feet square at the base; while at the summit, capped with stone, it is to be 8 ft. 6 in. across. A brick tunnel, 100 feet in length and of large size, will connect the great landmark with the apices of the several kilns. By being carried to so great an elevation, the irritating fumes from the kilns will be diffused over so great an area as to become practically harmless and inoffensive.

An Improved Transit.—At the last meeting of the Franklin Institute there was exhibited and described an instrument of this character, devised and manufactured by Messrs. Heller and Brightley of this city. The instrument is the kind known to engineers as the "long centre" transit; and the points of modification which the inventors claim as improvements, are here briefly condensed. The weight of the instrument is reduced one-half as compared to the ordinary long centre transit, while its size is not diminished in any part. This is accomplished by ribbing or bracing the plates and other solid parts, while every superfluous particle of metal not essential to the strength or steadiness of the instrument is removed.

The errors arising from the wear of the "tangent or slow motion screw," which in time becomes very serious, the inventors claim to have obviated by an improved tangent screw having the following construction. The nut consists of a long cylinder, from the interior of which two-thirds of the screw thread has been removed; into half the recess thus left in the cylinder, a cylindrical "follower" is fitted with the same length of thread as the nut. A "key" in the follower locking in the cylinder, prevents any rotary motion of the follower, but freely permits motion forwards or backwards. A strong spiral spring is placed in the remaining half of the recess, between the fixed nut and the movable follower, in such manner that it shall always possess tension enough to force the follower and fixed thread in opposite directions. The difficulty of lost motion in the screw is thus claimed to be removed. The tangent screw is attached to the plates by a modification of the "gimbelling" of the ship's compass,

* Mechanics Magazine, Sept., 1871.

so as to permit the screw to be tangent to the plates in every part of its length and not to bind.

An improved telescope, in which chromatic and spherical abberration are for practical purposes completely corrected, is also claimed.

The spiders web, hitherto used for cross hairs, being hygrometric, and hence liable in tunnel work, &c., to lengthen and shift the line of collimation, is replaced in the instrument here described, by cross hairs of platinum $\frac{1}{1000}$ of an inch in thickness. These being perfectly independent of this atmospheric source of error, and at the same time perfectly opaque, are a most valuable substitute.

The extremely thin wire, it may be mentioned, is manufactured upon the plan first suggested by Wollaston, of covering a thin wire of platinum with silver, drawing the two metals together, and subsequently dissolving off the surrounding silver from the central platinum.

A new use for the screw Propeller.*—M. Marten suggests the plan of attaching to sailing-vessels a screw-propeller, the motion of which shall be obtained from the movement of the ship. The author proposes to utilize the power so obtained, in giving motion to an electro-magnetic apparatus, from which such vessels may be supplied with the convenience of an electric light, thus dispensing with the use of oil, and gaining besides the advantage of the greatly increased illumination.

The Rotary Puddling Furnace.—The invention of Mr. Danks, noticed some months ago in this journal, by which the manual labor of puddling is performed entirely by a machine which he has termed the rotary puddling furnace, is at present attracting great attention from English iron-masters. The most glowing accounts of its performance have reached us from Cincinnati, where it was first put into operation. And if but a portion of these accounts are genuine, the machine puddler bids fair to work a great change in one of the most important branches of iron manufacture.

Dynamite.—The substitution of parchment for paper in the material of the cartridge cases intended to contain dynamite, (nitroglycerine absorbed by an inert powder,) is strongly urged by M. Guyot, who has found that the papers in which this substance is usually placed, soon become oily from having saturated themselves with

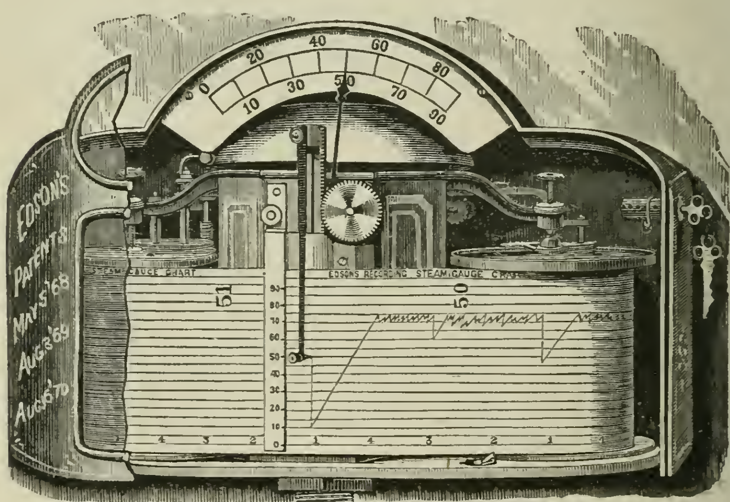
* Les Mondes, Aug. 24, 1871.

the nitro-glycerine. Small pieces of such paper were found to explode with violence when thrown upon glowing coals, or struck with a hammer. Even the wooden boxes in which it is transported, become after a time strongly impregnated with this dangerous compound.

The author points out very clearly that the facts here detailed may give rise to serious accidents, where this material is stored or used.

The use of parchment is recommended as a substitute for the paper, as the former being impervious to the liquid, no absorption of the nitro-glycerine can take place.

An Automatic Registering Steam Gauge.—As a matter of interest to many of our readers who may have heard of the fact that the Edson Steam Recording Gauge has recently been adopted by the U. S. Government Inspectors for use upon steamers, &c., in conformity with the recently enactly steamboat law (see this *Journal*, Vol. lxii, p. 223), we append herewith an illustration and description of its construction and working:



The gauge is connected with the boiler by means of a pipe, which allows the steam to act upon a series of corrugated discs, arranged

in pairs, and which are expanded by it. The motion thus produced is transmitted to a wheel (shown in the cut) by means of a lever.

This wheel communicates motion to a rack, carrying a pencil, which marks the varying degrees of pressure upon a band of paper, which receives its motion from the same source; the drum upon the left unwinding and that upon the right winding up the band.

At the side of the pencil will be seen a scale, by which the pressure momentarily recorded may be read with great convenience. With a rising pressure, the pencil marks a stroke directly upwards; when the pressure falls, a forward motion is communicated to the paper, and the recorded mark is at an angle. The record is an extremely delicate one, the line being composed frequently of an innumerable number of slight notches, so close together as to seem a horizontal line, the cause being the slight variation of pressure at the successive strokes of the engine—a few ounces at most.

The paper roll will last for many weeks, and when used up may be filed away for reference. Another device, suitably attached to the instrument, causes an alarm to be rung whenever the pressure exceeds that determined upon on locking the case. Unless steam is promptly lowered, the gong continues to sound for half an hour or more.

The whole contrivance is secured by combination locks, which prevents it from being tampered with; and the case is fronted with a glass plate, to allow passengers and others to inspect momentarily the condition of the steam in the boiler.

The Introduction of the Metrical System.—Since writing our last notice upon this important question, we have obtained some additional information through the kindness of Prof. J. E Hilgard, acting Superintendent of weights and measures. From this it appears that there are in the custody of the Treasury Department, at the office of weights and measures, the following authentic copies of the standard meter and kilogramme of France, viz.: Meter of platinum, compared and certified by Arago. Meter of steel, compared and certified by Silbermann. Kilogramme of platinum, compared and certified by Arago. Kilogramme of brass (gilt) compared and certified by Silbermann.

The length of the meter is 39·3685 inches of the United States standard scale, and the kilogramme is 15,432·2 grains, or 2 pounds, 3 ounces, 119·7 grains avoirdupois.

These numbers are exact for the meter within $\frac{3}{10000}$ of an inch; for the kilogramme, within $\frac{1}{20}$ of a grain. The standards obtained possess as great a degree of authenticity as can be obtained, and may be regarded as being as nearly perfect as they can be made.

In addition to the standards here enumerated, there is in the possession of the U. S. Coast Survey an iron meter, to which an unusual degree of authenticity is attached.

This instrument is the property of the American Philosophical Society, and is one of the twelve original meters made by direct comparison with the toise. A comparison between this bar and the standard of France at the Conservatory of Arts and Trades, was effected by Dr. F. A. Barnard, with the result, that at the temperature of melting ice there is no appreciable difference, by the most delicate means of comparison, between the platinum standard of the conservatory and the iron meter above named. It is therefore possible to reproduce the metric standards with all possible freedom from error.

The kind, form and verification of the standards to be supplied to the various States and Territories, was agreed upon by the National Academy of Sciences, and subsequently approved. The verification of each set is made in duplicate by different persons. At the date of the report from which we quote, the work of construction, adjustment and graduation is in a very advanced state.

Boussingault's Experiment with Confined Water.—The author relates the following experiment, conducted by him in order to test the condition of water, when cooled considerably below its normal freezing point, under circumstances where free expansion was prevented. For this purpose, a strong cylinder of steel was filled with water at the temperature of maximum density, and a steel plug tightly fitted to the opening, thus preventing, by the strength and the practically unyielding nature of the confining vessel, any expansion of the contained liquid when cooled. The sound made by the falling of a metal ball previously placed within the cylinder, gave an indication of the condition of its contents. Under these circumstances, Boussingault found that water remains liquid even at a temperature of —18° C. (—0·4° Fahr.), but freezes instantly as soon as the plug, which

hermetically sealed the vessel, is removed, and its particles are allowed full freedom to expand.

The Bending of Glacier Ice.—The announcement having been made that ordinary ice, when subjected to a transverse strain, would bend sufficiently to admit of measuring the extent of flexure, Tyndall, some time since, suggested that the same test should be applied to glacier ice. It has been left, however, for Prof. T. himself to carry out his suggestion, which he has done successfully. The ice was a rectangular bar from the Morteratsch glacier, and was suspended at the ends and weighted at the centre, the temperature being kept some degrees below the freezing point. After the lapse of ten or twelve hours a perceptible curvature was noticable. Whether or not this fact will, in any degree, affect the still-contested problem of glacier motion remains to be seen.

Transparent Lacs for Glass and Mica.*—F. Springmühl informs us that the aniline colors are particularly well adapted for the manufacture of transparent lacs, which possess great intensity even in very thin films, and are hence very suitable for coloring glass or mica.

The process recommended, is to prepare separately an alcoholic solution of bleached shellac or sandarach, and a concentrated alcoholic solution of the coloring matter, which last is added to the lac before using it, the glass or mica to be coated being slightly warmed. Colored films of great beauty may also be obtained, according to the author, from colored solutions of gun-cotton in ether, the coloring matter being here dissolved in alcohol and ether.

The collodion film has its elasticity greatly increased by the addition of some turpentine oil; and when applied cold can be removed entire. The colored films may now be cut into any pattern, and again attached to transparent objects.

The Bright Lines in the Spectrum of the Chromosphere.—Through the kindness of Prof. C. A. Young, Ph. D., we have obtained advance sheets of the Amer. Jour. of Science, containing an article upon the bright lines in the chromosphere, observed and catalogued by the author. The catalogue, which is a most valuable addition to our knowledge, is herewith appended. The only column needing a word of explanation is the seventh, in which the letters R., L. and J., refer respectively to Rayat, Lockyer and Janssen:

* Zeitsch. für Färberei, etc., No. 20, 1871.

Preliminary Catalogue of Chromospheric Lines.

Ref. No.	Kirchhoff.	Angstrom.	Rel. Frequency.	Rel. Brightness.	Chemical Element.	Previous Observer.	Ref. No.	Kirchhoff.	Angstrom.	Rel. Frequency.	Rel. Brightness.	Chemical Element.	Previous Observer.
*1	534·5	7060·?	60	3			53	1673·9	5153·2	1	1	Na.	
2	654·5	6677·?	8	4		L.	54	1678·0	5150·1	1	2	Fe.	
3	C	6561·8	100	100	H.	L. J.	55	1778 5	5077·8	1	1	Fe.	
4	719·0	6495·7	2	2	Ba.		56	1866·8	5017·5	2	3		R.
5	734·0	6454·5	2	3			57	1870·3	5015·?	2	2		R.
6	743·?	6431·	2	2			58	1989·5	4933·4	8	5	Ba.	L.
7	768·?	6370·	2	2			59	2001·5	4923·2	5	3	Fe.	R.L.
8	816·8	6260·3	1	1	Ti.		60	2003·2	4921·3	1	1		
9	820·0	6253·2	1	2	Fe.		61	2007·1	4918·1	3	3		L.
10	874·2	6140·5	6	8	Ba.	L.	62	2031·0	4899·3	6	4	Ba.	L.
11	D_1	5894·8	10	10	Na.	L.	63	2051·5	4882·5	2	2		L.
12	D_2	5889·0	10	10	Na.	L.	64	F.	4860 6	100	75	H.	J. L.
*13	1017·0	5871·	100	75		L. J.	65	2358·5	4629·0	1	1	Ti.	
14	1274·3	5534·0	6	8	Ba.	R. L.	66	2419·3	4683·5	1	1		
15	1281·5	5526 0	1	1	Fe.		67	2435·5	4571·4	1	1	Li.	
16	1343·5	5454·5	1	2	Fe.		68	2444·0	4564·6	1	1		
17	1351·3	5445·9	1	2	Fe. Ti.		69	2446 6	4563·1	1	2	Ti.	
18	1363·1	5443·0	1	1	Fe.		70	2457·8	4555·0	1	1	Ti.	
*19	1366·0	5430·0	2	3			71	2461·2	4553·3	3	3	Ba.	
20	1372·0	5424·5	3	4	Ba.	L.	72	2467·7	4548·7	1	3	Ti.	
21	1378·5?	5418·0?	1	2	Ti.?		73	2486·8	4535·2	1	1	Ti. Ca.?	
*22	1382·5	5412·	1	1			74	2489 5	4533·2	1	1	Fe.	
23	1391·2	5403·0	2	2	Fe, Ti.		75	2490·6	4531·7	1	1	Ti.	
24	1397·8	5396·2	1	2	Fe.		76	2502·5	4524·2	2	2	Ba.	
25	1421·5	5370·4	1	2	Fe.	R.	77	2505·8	4522·1	1	2	Ti.	
26	1431·3	5360·6	2	2		R.?	78	2537·3	4500·4	1	3	Ti.	
27	1454·7	5332·0	2	2	Ti.		79	2553·?	4491·0?	1	1	Mn.?	
28	1462·9	5327·7	1	3	Fe.		80	2555·?	4489·5?	1	1	Mn.?	
29	1463·4	5327·2	1	3	Fe.		81	2566·5	4486·4	1	2	Mg.	L.
30	1465·0?	5321·	2	2			82	2581·5?	4471·4	75	8	A band rather than a line.	
							83	2585·5	4468·6	1	1	Ti.	
31	Corn'a line 1474·1	5315·9	75	15	Fe.?	L.	84	2625·0	4443·0	1	1	Ti.	
32	1505·5	5283·	5	4			85	2670·0	4414·6	1	1	Fe. Mn.	
33	1515·5	5275·0	7	5		L. R.	86	2686·7	4404·3	1	2	Fe.	
34	E_1	5269·5	1	3	Fe, Ca.		87	2705·0	4393·5	3	2	Ti.	
35	E_2	5268 5	1	2	Fe.		88	2719·?	4384·8	1	1	Ca.?	
36	1528·0	5265·5	3	2	Fe, Co.	L.	89	2721·2	4382·7	1	2	Fe.	
37	1561·0	5239·0	1	1	Fe.		90	2734·?	4372·	1	1		
38	1564·1	5236·2	1	1			91	2737·?	4369·3?	1	1	Cr.?	
39	1567·7	5233·5	2	2	Mn.	R.	92	2775·8	4352·0	1	1	Fe. Cr.	
40	1569·7	5232·0	1	2	Fe.		93	2796·0	4340·0	100	50	H.	L. J.
41	1577·3	5226·0	1	2	Fe.		94	G.	4307·0	1	2	Fe.Ti.Ca.	
42	1580·5?	5224·5	1	1	Ti.		95	2770 0	4300·0	1	1	Ti.	
43	1601·5	5207 3	3	3	Cr.Fe.?		96		4297·5	1	1	Ti. Ca.	
44	1604·4	5395·3	3	3	Cr.		97		4289·0	1	2	Cr.	
45	1606·5	5203·7	3	3	Cr,Fe.?		98		4274·5	1	2	Cr.	
46	1609·3	5201·6	1	2	Fe.		99		4260·0	1	1	Fe.	
47	1611·5	5199·5	1	1			100		4245·2	1	1	Fe.	
48	1615·6	5197·0	3	2		L.R.	101		4226·5	1	1	Ca.	
49	b_1	5183·0	15	15	Mg.	L.	102		4215·5	1	2	Fe. Ca.	
50	b_2	5172·0	15	15	Mg.	L.	103	*h*	4101·2	100	20	H.	R.L.
51	b_3	5168·5	12	10	Ni.	L.							
52	b_4	5166·5	10	10	Mg.	L.							

A Volcano in Miniature.*—Dr. Ferd. V. Hochstetter furnishes an interesting account of a phenomenon occurring during one of the phases of a manufacturing operation, which is, as he claims, a complete duplicate, upon a miniature scale, of a volcanic eruption, and which serves, at the same time, to confirm the modern views concerning the process of an eruption; according to which the lava is not simply in a molten condition, but is reduced to the state of liquidity by the action of superheated water-vapor under great pressure.

The phenomenon referred to occurs in the operation of separating the sulphur from the residual products obtained in the manufacture of soda by Leblanc's process. The sulphur obtained from these residues, in order to free it from the gypsum or sulphate of lime mixed with it, is melted in a suitable apparatus, with steam under a pressure of from 2—3 atmospheres. The gypsum remains suspended in the water, and the fused sulphur is from time to time run off into wooden troughs or forms, the temperature of the fluid mass being about 122°C. (251·6°F.) Almost instantly after the pouring, a crust of solid sulphur is formed on the surface of the mass. Dotted over this surface, however, the orifices are left, from which the liquid beneath is forced up. At intervals a jet of sulphur bubbles out, and cooling, forms around the orifice a slight prominence; the repeated eruptions accumulate material about it, until a miniature volcanic cone is formed, with its crater well defined.

The cause of this curious phenomenon is found in the fact that the sulphur, in its fused condition in the steam chamber, takes up and retains a certain quantity of water; and this absorbed water, it appears, is given out gradually in the form of steam, as the sulphur solidifies. The slowly liberated steam accumulating pressure beneath the crust of sulphur, forces, at regular intervals, an outlet at the vents, carrying with it in its passage the molten material to form the solid cone.

An Explosion (?) upon the Sun.—The following interesting account of a very unusual disturbance upon the sun, from the pen of Prof. C. A. Young, will shortly appear in the *Boston Journal of Chemistry*, from advanced sheets of which we print it in full.

On the 7th of September, between half past twelve and two P. M., there occurred an outburst of solar energy remarkable for its sudden-

*Neues Jahrbuch für Mineralogie, 1871, p. 469.

ness and violence. Just at noon the writer had been examining with the telespectroscope* an enormous protuberance of hydrogen cloud on the eastern limb of the sun.

It had remained with very little change since the preceding day—a long, low, quiet looking cloud, not very dense or brilliant, nor in any way remarkable except for its size. It was made up mostly of filaments nearly horizontal, and floated above the chromosphere† with its lower surface at a height of some 15,000 miles, but was connected to it, as is usually the case, by three or four vertical columns brighter and more active than the rest. Lockyer compares such masses to a banyan grove. In length it measures 3′ 45″, and in elevation about 2′ to its upper surface—that is, since at the sun's distance 1″ equals 450 miles nearly, it was about 100,000 miles long by 54,000 high.

At 12.30, when I was called away for a few minutes, there was no indication of what was about to happen, except that one of the connecting stems at the southern extremity of the cloud had grown considerably brighter, and was curiously bent to one side; and near the base of another at the northern end a little brilliant lump had developed itself, shaped much like a summer thunder-head.

What was my surprise, then, on returning in less than half an hour (at 12.55), to find that in the meantime the whole thing had been literally blown to shreds by some inconceivable uprush from beneath. In place of the quiet cloud I had left, the air, if I may use the expression, was filled with flying *débris*—a mass of detached vertical fusiform filaments, each from 10″ to 30″ long by 2″ or 3″ wide, brighter and closer together where the pillars had formerly stood, and rapidly ascending.

When I first looked some of them had already reached a height of nearly 4′ (100,000 miles), and while I watched them they rose with a motion almost perceptible to the eye, until in ten minutes (1.05) the uppermost were more than 200,000 miles above the solar surface. This was ascertained by careful measurement; the mean of three closely accordant determinations gave 7′ 49″ as the extreme altitude attained, and I am particular in the statement because, so far as I

*This is the name given to the combination of astronomical telescope and spectroscope.

† The *chromosphere*, (called also *sierra* by Proctor and others) is the layer of hydrogen and other gases which surrounds the sun to a depth of about 5,000 miles. Of this the prominences are mere extensions.

know, chromospheric matter (*red hydrogen* in this case) has never before been observed at an altitude exceeding 5′. The velocity of ascent also, 166 miles per second, is considerably greater than anything hitherto recorded.

As the filaments rose they gradually faded away like a dissolving cloud, and at 1.15 only a few filmy wisps, with some brighter streamers low down near the chromosphere, remained to mark the place.

But in the meanwhile the little "thunder head," before alluded to, had grown and developed wonderfully, into a mass of rolling and ever-changing flame, to speak according to appearances. First it was crowded down, as it were, along the solar surface; later it rose almost pyramidally 50,000 miles in height; then its summit was drawn out into long filaments and threads which were most curiously rolled backwards and downwards, like the volutes of an Ionic capital; and finally it faded away, and by 2.30 had vanished like the other.

The whole phenomenon suggested most forcibly the idea of an *explosion* under the great prominence, acting mainly upwards, but also in all directions outwards, and then after an interval followed by a corresponding inrush; and it seems far from impossible that the mysterious coronal streamers, if they turn out to be truly solar, as now seems likely, may find their origin and explanation in such events.

The same afternoon a portion of the chromosphere on the opposite (western) limb of the sun was for several hours in a state of unusual brilliance and excitement, and showed in the spectrum more than 120 bright lines whose position was determined and catalogued,—all that I had ever seen before, and some 15 or 20 besides.

Whether the fine Aurora Borealis which succeeded in the evening was really the earth's response to this magnificent outburst of the sun is perhaps uncertain, but the coincidence is at least suggestive, and may easily become something more if, as I somewhat confidently expect to learn, the Greenwich magnetic record indicates a disturbance precisely simultaneous with the solar explosion.

C. A. Young.

Dartmouth College, September, 1871.

On the Origin of Life.—The address of Sir William Thompson, to the British Association, is in everything relating to physics a most masterly review of the present condition of science, from one who is a recognized leader in modern scientific thought and research. It is therefore with considerable surprise, after so thorough and ex-

haustive an exposition of the state of knowledge in those branches, that we read his concluding sentences upon the origin of life on the earth. Utterly repudiating, as unworthy of credence, the doctrine of spontaneous generation, so vigorously maintained in our own times by Pasteur, Pouchet and Bastian, he suggests the following curious substitute, for the paternity of which his claim, we are inclined to believe, will never be disputed.

Referring to the case of a volcanic island, suddenly emerging from the sea, and becoming in a few years clothed with vegetation through the agency of seeds transported to it from the sea and air, he inquires whether it may not be possible, or even probable, that the beginning of vegetable life upon the earth may be explained in a similar manner. Every year millions of fragments of solid matter—meteoric stones—fall upon the earth, and he conceives that these foreign visitants may be the fragments of worlds beyond ours, scattered in every direction through space, by collision with another, bearing upon them seeds, living animals and plants, which might be deposited, still endowed with life, wherever they may chance to find a final resting place. "The hypothesis," he continues, "that life originated on this earth through moss-grown fragments from the ruins of another world, may seem wild and visionary; all I maintain is that it is not unscientific."

With the alternative before them of accepting the views of the learned physicist, it would scarcely prove a subject of surprise to hear that the advocates of spontaneous generation refuse to be moved from their position.

Nitrate of Silver and Charcoal.—Dr. Chandler* communicates the following interesting item, in connection with the materials above named:—When solid nitrate of silver is placed upon glowing charcoal, deflagration takes place, the result being that the silver is left behind in the metallic state. The curious phenomenon attending the reaction is that the nitrate, being fused by the heat of the chemical action, sinks down into the pores of the coal, and as each particle of the latter is replaced by the reduced silver, the structure of the original wood is retained.

Dr. C. states that he has succeeded in this way in producing masses of silver weighing an ounce or more, which show most beautifully the rings of annual growth in the wood. The author directs that a crystal of the nitrate be placed on the end of a stick of charcoal, and the

* American Chemist, September, 1871.

blowpipe flame directed upon the coal beside it to start the reaction. As soon as the deflagration sets in, crystal after crystal may be added.

A New Mode of Preparing a Common Reagent.*—Mr. John Galletly communicates the fact that a mixture of equal parts of sulphur and paraffin (or with a larger proportion of sulphur) when heated in a flask to a temperature not much above the melting point of the sulphur, will evolve sulphuretted hydrogen with great steadiness. The author recommends the process as the most convenient of any yet devised for laboratory use. Where a pound of the material is used in a suitable generating vessel, the evolution of gas may be prolonged for several days with great regularity. The production of the reagent can be stopped and renewed at pleasure by withdrawng or applying the lamp.

New Gas Forge.—The American Chemist contains the description of an apparatus of this kind, having the following construction: There is claimed for it a degree of heating power, sufficient to fuse bronze, copper, gold and silver. The principle is that of the Bunsen burner, (in which the burning gas is mixed with a supply of air before combustion), but differs from the ordinary burner in having the openings through which the gas enters some distance above those supplying the air. Encircling the tube through which the mixture passes is an outer tube, open above and below, by which an additional supply of air is furnished to the flame, and the draught is increased.

Phosphorus Bronze.—In connection with the item mentioned in our last issue, it may be in place to add, that experiments are at present being made in France, upon an extensive scale, to test the value of the addition of small quantities of phosphorus to various alloys of copper and zinc, especially in relation to the manufacture of bronze guns, in the construction of which especial advantages are claimed for these alloys.

Selenitic Mortar.—Col. Scott, R. E., has lately invented a process of producing mortar which is asserted to possess decided advantages.

The peculiarity of the process consists in mixing with the water used a small quantity of gypsum or plaster-of-Paris, or by adding green vitriol. The mixture is made in the pan of an ordinary mor-

* Chem. News. xxiv, 162.

tar mill, the water and gypsum being first introduced, and then the lime. After grinding the lime for a short time, the sand, burnt clay, or other materials are added, and the whole mass is ground for ten minutes longer. By this process, it is said a cement-mortar can be obtained which sets quickly, and can be used for concrete, bricklayers' work &c., cheaper than the ordinary material. Tests made with this mortar against Portland cement—under the same conditions—gave a result in favor of the former, the breaking weights of the two materials being 156 lbs. (mortar) and 58 lbs. (cement).

Statistics of Population.—The following curious calculation is extracted from a letter received from a well-known engineer. It may prove of interest to our readers.

* * * * * * * * *

Sir John F. W. Herschell, in a foot note pp. 455 and 456 of "Familiar Lectures on Scientific Subjects" (Alexander Strahan & Co., London, 1866), says: For the benefit of those who discuss the subject of population, war, pestilence, famine, etc., it may be as well to mention, that the number of human beings living at the end of the hundredth generation, commencing rom a single pair, doubling at each generation (say in thirty years) and allowing for each man, woman and child, an average space of four feet in length, and one foot square, would form a verticle column, having for its base the whole surface of the earth and sea spread out into a plain, and for its height 3674 times the sun's distance from the earth. The number of human strata thus piled one on the other, would amount to 460,790,000,000,-000. So far Mr. Herschell. In attempting to verify his figures, I find, according to those last above quoted, that he calls the sun's distance from the earth 95,000,000 miles.

This is too much according to recent determinations. It is now set down (see The Sun. Richard A. Proctor, London, Longmann, Green & Co, 1871, p. 64) at about 92,000,000 miles, equal to 485,760,000,000 *feet*, equal to 121,440,000,000 *strata* of four feet each in the sun's distance from the earth. J. C. HOADLEY.

Civil and Mechanical Engineering.

INTEROCEANIC COMMUNICATION ACROSS CENTRAL AMERICA.

By Prof. J. E. Nourse.

(Continued from page 167.)

Disposition of the Colonies after obtaining Independence.

In the history of the plans for communication between the two seas, Mexico and the Central American States appear in somewhat enviable contrast with their old masters. The persistently stupid mandates of the Spanish Court had consigned the idea of an open route to *official* oblivion. They could not blot it for one moment from the minds of the merchant or the statesman.

Two remarkable eras had indeed existed, at each of which either Spanish or British power might, at least, have effected vast improvements in the miserable highways from the Pacific, over which the jaded animals of the trains plodded with their treasures. At each of these eras the full scheme was broached of an open navigation. It was listened to, approved, talked of, and dropped by the men in power. To detain a few moments in memory of these eras will not be profitless.

The first was at the close of the seventeenth century. It was the seemingly romantic but wise plan of William Paterson, the founder of the Bank of England. He conceived the idea of securing for his countrymen, the Scotch, an independent colonial establishment in Darien, in which they could reap the gains of trade from both oceans. He wanted for them and for the English some share in the marvelous returns realized by such companies as the Dutch East India Co., the English E. I. Company being then unformed. To establish such a colony, became the ruling idea of his life. "This object," says a late biographer who revives well earned tributes to Paterson's memory, "merited the praise given it in the last century, of being calculated to improve the policy of all civilized States in the Western Hemisphere; and the important events of *the present day in the same regions*, bring out his genius as a statesman in the most brilliant light." ("Paterson's Writings, Bannister; London, 1859.")

The attractive details of his scheme; his voyage to Darien—touching at the New York of 1698; his establishment of a colony of 1200

stalwart Scotch who, but for their and his pacific purposes, might have overturned Spanish rule in America; the support of his company by capitalists in London, Hamburg and Amsterdam, despite the opposition of the Dutch East India Co.; the vaccillating policy of the English King ending in neglect, and finally in cruel opposition; and the end of the colony at Caledonia after Campbell's heroic resistance to the Spanish fleet; are matters of strange history. It is known that the lamented Warburton was on the very journey to Darien, to work up these exploits of that land into a historic romance, when he perished on the ill-fated Amazon in 1852.

Sir John Dalrymple's Memoirs of Gt. Britain and Ireland, 1790, give us Paterson's true aims. "This door of the Seas and key of the Universe—Darien"—says Paterson, "with anything of a reasonable management, will enable its proprietors to give laws to both oceans without being liable to the fatigues, expenses and dangers of contracting the guilt and blood of Alexander and Cæsar."

There is a further passage in one of Paterson's letters which seems so prophetic of America that we cannot pass it by. "But if neither Britain singly, nor the maritime ports of Europe will treat for Darien, the period is not very distant when instead of waiting for the slow returns of trade, America will seize the pass of Darien. Their next move will be to hold the Sandwich Islands. Stationed thus in the middle, on the east, and on the west sides of the New World, the English Americans will form the most potent and singular Empire that has appeared, because it will consist not in the dominion of a part of the land of the globe, but in the dominion of the whole ocean. They can make the tour of the Indian and Southern Seas, collecting wealth by trade wherever they pass. During European wars they may have the carrying trade of all. If blest with letters and arts, they will spread civilization over the universe. Then England, with all her liberties and glory, may be known only as Egypt is now."

Reading these words of Paterson's, we are tempted to ask why, but for English blindness and folly, was this colony—the pride of Scotland, the whole population of whose city, Leith, turned out to see it embark—why was it so cruelly opposed and killed by the home and foreign authorities of England? And why, in our day, but for some suicidal blindness of our own land bringing about this sad decay of the American marine, is not America already ruling, as predicted, both oceans? And why shall we not now pursue until successful the opening up of a navigable transit from sea to sea, which shall aid in recovering our destined supremacy in commerce?

Pass we *one century* forward strangely enough to find the other era in the far past in which something hopeful seemed to dawn on the prospect of intercommunication across Central America. It was the era of the proposed emancipation of these States in 1797. In that year proposals were offered by Genl. Miranda, of New Grenada, and by Commissioners from Mexico and other States to Mr. Pitt, the sixth article of which stipulated "the opening of the navigation between the Atlantic and Pacific oceans, through Panama and through Nicaragua."

Mr. Pitt entered into the scheme promptly and cordially. Miranda wrote most hopefully of it to Alexander Hamilton. The plan asked also of the United States 10,000 troops, to aid in emancipating the Colonists from Spain, the British Government agreeing to find the ships and money. But President Adams following, doubtless, Washington's well-known policy of non intervention, declined an immediate answer, and the measures were postponed. The scheme is not cited here as having contained good ground of expecting to secure then a full interoceanic transit, since the progress of that age had not secured the necessary engineering skill, power, or facilities. The historic era is, however, worth nothing.

It was then that the Edinburg *Review* sufficiently appreciated the idea of a navigable passage across the Isthmus, to write in bold terms thus: "This is the mightiest event, probably, in favor of the peaceful intercourse of nations which the physical circumstances of the globe present to the enterprise of man. It is the same thing as if, by some great revolution of the globe, our eastern possessions were brought near us. Immense would be the traffic which would immediately begin to cover that ocean, by denomination, Pacific. * * * *China and Japan*, brought so much nearer European civilization, would not be able to resist the salutary impression, but would soon receive *important changes in ideas*, arts and manners."—*Edinburg Review*, vol. xiii.

As these words are quoted to-day, the presence before the writer of more than twenty young Japanese curiously engaged in their inquiries at the National Institutions of Washington, the remembrance that tons of American works on education have been sent from the United States to Japan, and that an invited Commission of some of our chief citizens is now on its way to benefit that Empire in agricultural pursuits,—forcibly seal the prophecy of the reviewer, that important changes of ideas would come over the Asiatics. But they

are those of American, not of European civilization. They are the influence of the very people who, the cruelly treated Patterson foresaw, would become potent.

They have become potent by the genius of men little dreamed of by the Edinburg reviewer—by inventions and works not within his range of vision—by the printing press of Franklin, the steamboat of Fulton, the telegraph of Morse—by the energy and endurance of the Tottens, and Stephens, and Hoadleys and Huntingtons, who have already twice spanned the continent with a Western Railroad.

But it is full time that we come back,—hopeful of the reader's indulgence,—to the chronicle of the American Republics in relation to interoceanic transits. The governments of Central America, so far as at any time they have been dignified with the name, have often shown a very favorable disposition towards the opening of transits from sea to sea. Notwithstanding the difficulties incident to their protracted struggle for freedom, and their new and unsettled political and social condition, they seem to have opened the door to enterprise; have encouraged applications for permissions to explore and survey the routes; have lent a ready ear to the propositions of capitalists and even of adventurers in this field. Fuller notices of this more properly connect themselves with brief narratives to be given of each of the routes. Suffice it here to say that the great Humboldt obtained from Gen. Bolivar, the "*Liberator*," "the Geodesic survey of the Isthmus of Panama;" that in 1837–'38 lake Nicaragua, and the river San Juan and the isthmus lying between the lake and the port, were surveyed by Bailey at the request of Gen. Morazan, then President of the Republic; that in 1842, under the Presidency of Santa Anna, Garay's survey was made by Moro and others across Tehuantepec; that in the same year urgent solicitations were made by leading men in Central America through Castellon, to the late Emperor of France, urging him to come over and personally undertake the work of a ship canal across lake Nicaragua, a proposition previously laid before the King of Holland; that within the last ten years very many sincere advances have been made, and propositions from capitalists and corporations have been readily accepted, and charters thereupon issued by the several Central American States towards the execution of the great work, the ship canal, as well as the less important works of railroads across from sea to sea. The British Vice-Consul at Panama, in 1865, tells us that in the spring of that year, "applications were presented

to the Congress of Bogota by two companies and three firms for the privilege of cutting a canal." It is stated, in the able report on this subject of interoceanic communication, made in 1839 to the U. S. House of Representatives by the Chairman on roads and canals, Hon. C. Fenton Mercer, that while the states of S. America, "exhausted by their struggle for independence and by internal commotions, could not be expected to undertake such works without foreign capital, they have demonstrated their sense of its importance, and have shown a readiness to receive aid from foreign nations, manifesting a disposition to waive, for the welfare of mankind, every narrow and local interest."

To this it may be added that the patience of these governments has been sometimes tried, and their just expectations disappointed when they have cordially and equitably made grants to individuals and companies, professing to obtain them for the opening of some important route. The New Granadian Minister Plenipotentiary to the French Court in 1860, thus wrote to a French company undertaking an exploration: "Commence by exploring in Darien, for there you have ground for hope; you need not fear to spend money there, for the maritime canal is possible nowhere else. * * *

"*My government has reason to be weary of granting* concessions of mines and lands to persons who look for nothing from the grants but some *immediate* money-making scheme. These concessions change hands; no one regards the terms, and so the non-suiting of the parties and foreclosing of the contract is usually the end of the matter."

Chronicle of Efforts to secure Interoceanic Transits.

Instructions of Charles V. to Cortez, 1534; Antonelli sent by Philip II. to explore Nicaragua; three routes urged by Gomara, 1554; Paterson's "Four passes," 1701; proposals by citizens of Oaxaca, 1715; Tehuantepec route explored by Cramer, 1774; exploration of the San Juan by Galisteo, 1781; Miranda's proposals to William Pitt, 1797; decree of Span. Cortez for canal across Tehuantepec, 1814; surveys under Bolivar, 1827; Holland company formed, 1830; Mission of Col. Biddle, 1836; Bailey's survey of Nicaragua, 1838; proposals to Louis Napoleon, 1840; Garay's survey of Tehuantepec, 1842; Garella's survey of Panama route, 1843; Dr. Cullen's explorations, 1849; William's survey of Tehuantepec, 1850–51; Child's survey of Nicaragua, 1851; Panama R. Road, 1855; survey of Honduras route, by Squier, 1854, by Trautwaine, 1858; Lt. Strain's, Gisborne's and Prevost's crossing of Darien, 1854; surveys of the Atrato Route for Kelley, 1853–55; Lt. Michlel and Lt. Craven's survey of the Atrato, 1858; Bourdiol's expedition, 1861; Pim's expedition, 1864; De Puydt, 1865; Lacharme and Flachat, 1866; Commander Selfridge, Darien, 1869—71; Capt. Schufeldt, Tehuantepec, 1870.

(To be continued.)

A FEW ADDITIONAL FACTS IN RELATION TO THE TESTING OF THECAPACITY OF BOILERS.

By S. L. Wiegand.

The fact of the writer of this communication appearing as a participant in a report rendered to the parties pecuniarily interested in a test of boilers, described to the Institute at the monthly meeting in January last, and published in the March number of the *Journal*, seems a sufficient warrant for stating some additional facts in relation to the conditions under which the test was made.

The prime object of the investigation of the power of boilers appears to be to satisfy or dissatisfy the purchasers of steam boilers with their purchases.

Having had the opportunity of observing that the endeavor is being made to procure for the method of testing boilers above referred to, the sanction and approval of this Institute, an opportunity is desired to submit all the facts of that test.

All questions involved between the sellers and the purchasers having been settled and finally adjusted, and the results having been published, there can be no impropriety in submitting all of the facts of the case to the Institute and the public.

Two boilers of the pattern known as double tank were erected in separate and contiguous furnaces, each boiler having 500 feet of heating surface and 16 square feet of grate surface.

The steam from these boilers passed into two pipes of six inches diameter and five feet in length, and thence, through 28 feet of pipe 4 inches in diameter, into a steam drum 14 feet long and 30 inches in diameter, and thence, through a pipe 4 inches in diameter and 12 feet long, to the engine. All of the pipes and drum were unprotected by clothing, and in well-ventilated apartments.

The engine has been correctly described as 4 feet stroke and 16 inches bore of cylinder.

The proper speed of the engine was 55 revolutions per minute. The cylinder of the engine was covered with a lagging of black walnut, one inch thick, leaving an air space of two inches between the lagging and cylinder.

The slide valve was so proportioned and adjusted as to admit steam to the cylinder the moment the crank passed the centres, and to close in the last two inches of the stroke.

The exhaust opened at the last half inch of the stroke, and remained open until the last half inch of the returning stroke.

When the boilers were erected the Tremper cut-off was placed as close to the steam-chest as it was possible to have it, and there appeared to be no difficulty for some time in maintaining the speed of the engine at 55 revolutions, and in keeping the steam blowing off at the safety valves, which were set at 120 lbs. per sq. in. Whilst supplying steam to a 500 lb. Morrison hammer, a pressure of 100 lbs. per sq. in. was adequate to maintain the speed at 55 revolutions, and diagrams showing 88-horse-power have been taken by a McNaught in dicator at that speed.

When the engine was running at its proper speed, the initial pressure of steam in the cylinders was always from 15 to 17 lbs. less than that of the boiler.

There was not enough work or resistance upon the engine to show larger diagrams, although the steam could be kept blowing off.

The McNaught indicator, as being unreliable (for reasons not explained), and the writer, owing to a presumption of being an interested party, were objected to by a disinterested engineering firm, and upon their suggestion Mr. Brown was engaged to take diagrams with a Richard's indicator.

A difficulty arose in feeding the boilers. The water was pumped from an open heater (that is, a heater in which the feed-water is showered in a vessel forming part of the exhaust-pipe and in contact with the exhaust steam, condensing a portion of it) by a plunge pump operated by the engine.

The same man acted both as engineer and fireman.

A change of engines was made, and it became difficult to run all the machinery and maintain the speed and steam pressure.

The engineer left his situation without notice, and the Tremper governor was found to be broken so as to be entirely inoperative.

The purchasers of the boiler expressed doubts as to the boiler being capable of developing 100-horse-power collectively.

A Throttle governor (Shive's) was applied, and a test by indicator was demanded by the purchaser.

The slide-valve remained in the adjustment, that has already been described.

An accident, maiming a workman entangled in a belt on the main line shaft of the factory, interrupted the discussion, and prevented such a test.

The makers of the boiler refused to be bound by any test so made. A Tremper governor was then applied, with a short pipe intervening between the cut-off valve and steam-chest.

The tests described were then made.

It was objected by the writer that the steam pipe and steam drums should be protected from radiation, and that the entire draught of the chimney should be used for the boiler, there being at the time an opening into the flue which was imperfectly closed by a damper that had been warped by heat.

The purchasers declared that, unless a test was made then and under the existing conditions, they would replace the boilers with others.

The makers, having no choice but to submit to the test or have the boilers removed without test, concluded to submit to the test.

The purchasers declined to allow the boilers to be fired by the man who had first run them successfully.

A fireman was engaged from a neighboring mill, who worked to the best of his ability.

The diagrams as exhibited to the Institute are correct representations of those drawn by the instrument on that occasion. The calculations of the diagrams are believed by the writer to have been correctly made.

After the test had been concluded the makers, at their own cost, furnished the purchasers an additional boiler of such size as to furnish the complement of 100-horse-power, by the rating obtained from the diagrams in the test.

The writer would respectfully submit that such a mode of testing exhibits not the full capacity of the boiler, but is vitiated by the infirmities of the steam connection, the defects of draft, and quality of fuel.

Since the erection of the additional boiler, the pipes and steam drum have been covered with non-conducting material, the defect in the water supply remedied, the apertures leading from the boiler to the steam pipe increased in both number and size, and the work upon the engine greatly augmented. Complete satisfaction with the performance of the boiler is expressed by the purchasers.

The test above referred to has been cited in evidence in a case now in litigation, with a view to prove that another boiler sold by the same party, differently proportioned and constructed, had not the power which the purchaser expected to realize.

There is not, so far as the knowledge of the writer extends, any necessity for measuring the capacity of a boiler by a steam engine; and, since the same quantity of steam may be made by expansion to develop more than twice the dynamic effect that is possible without expansion, there does not seem to be any proper inducement to have recourse to such a mode of measuring.

Another plan has been pursued which, when the boiler is capable of slightly superheating the steam, avoids the objection to that by the indicator. It consists in measuring the feed-water, and noting the temperature of it, and in maintaining a uniform pressure of steam, and observing to maintain the temperature of steam above that indicated by Reynold's table for saturated steam of that pressure.

To institute any just comparison of evaporative capacity between different boilers, it is believed the following conditions should be stated, and, if practicable, made equal: the grate surface, the heat absorbing surface, the quality and size of fuel, the quantity of air consumed in a given time, the temperature of the feed-water, the temperature and pressure of the steam generated.

For a comparative test of economy, the following data would seem requisite:

The quantity of fuel consumed to evaporate a given quantity of water, the cost of the boilers relatively to their evaporating capacity.

Any difficulty about the correct expression of the result can be easily avoided by stating it in known and established measures, as in lbs. or in cubic inches, instead of attempting to convert it into an expression of horse-power.

It would be well to determine with definite exactness, where and how the power is to be measured, if it be in foot pounds and must be expressed in horse powers, without expansion at the boiler.

Dr. Ure tells us, in the supplement of his dictionary, that 900 cubic inches of water converted into steam, afford 1,980,000 ft. lbs., which, if converted into the usual standard of horse power and time, is one horse power for one hour.

Now, if the steam be used expansively, the dynamic effect may be more than doubled. Should the makers of boilers be compelled to adapt their operations to meet the requirements of the best practice in engine construction, or the worst, or what intermediate class of works?

So far as avoiding disappointment to some purchasers is concerned, it has so far been beyond the ability of any boilers makers.

There are men who employ steam power who frankly say that they have no faith in indicator diagrams, and that they don't consider that they have derived any power from their boilers until it has passed into the driving band, and begins to do the work they want it for. In short, they believe the piston duty of an engine, as shown by indicator diagrams, may represent a great deal of power wasted in the engine itself.

How must such men be satisfied ?

Is it not sufficient, after accurately describing to the purchaser the boiler in all its parts and dimensions which it is proposed to make for him, and delivering the boiler exactly as described, to warrant the conclusion that the seller has been just to the buyer, without engaging in the presumption of a contract to furnish horses power for the determination of which, as yet, no definite method has been established, and which, if established, must be empirical ?

It may be objected, that business men, in buying boilers, may be misled by reason of not understanding steam engineering, and that some protection should be afforded them in such matters. But they have at command the same protection in that matter that others have when engaging in operations which they do not understand. They can employ the skill that they themselves have not.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Concluded from page 248.)

Veneers.

Veneered surfaces in wood-work, although unpopular to some extent as a "sham," have many claims that are overlooked by those that are not acquainted with the operation of veneering, and do not consider the matter mechanically. By the use of veneers we are able to construct on cabinet work with surfaces of the beautiful and variegated, crotch, motley or birds-eye wood, which it would be impossible to use unless glued to a "ground" of some more stable and trustworthy material, for in wood, as in many other things in nature, the plainer the appearance the greater the merit. The strength of wood as well as its tendency to "warp" or "spring," is, as a rule, determined by the regularity and straightness of the grain, and such wood as makes the most beautiful veneers is in the same degree use-

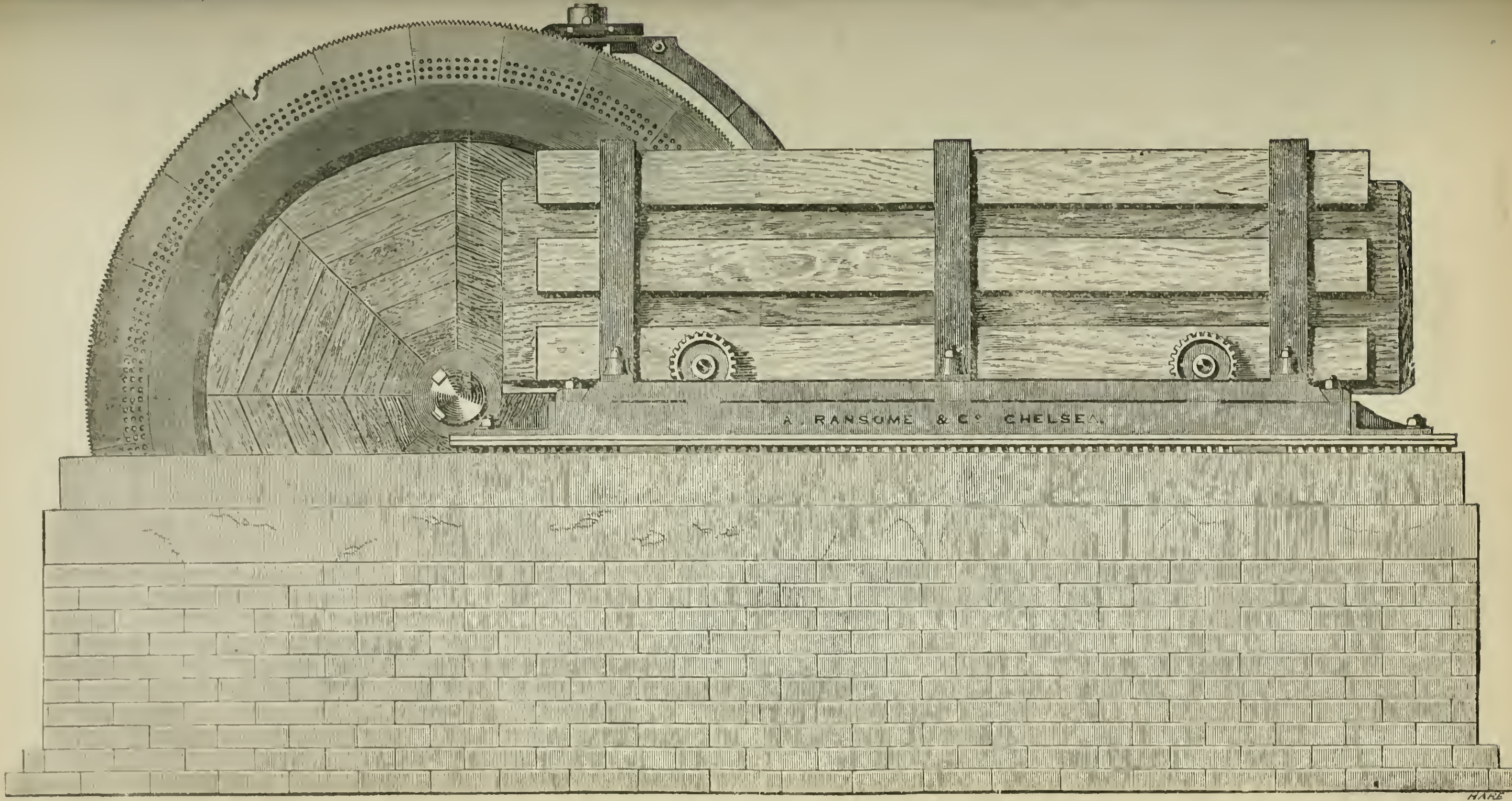


Fig. 1.

less for any other purpose than ornamentation. In short, wood work cannot be both handsome and strong if made from solid material; hence the system of veneering.

Veneers are usually laid on a backing of good dry pine; the most reliable and cheap are in our American markets. It not only "stands" well when seasoned, but is sufficiently porous to give a good glue surface, without which veneers are liable to peel off with age or dampness. To "lay" veneering in a proper and reliable manner, not only requires skill on the part of the workmen, but calls for a sound judgment of many conditions, which, if not carefully considered, ends in failure.

The porosity of the wood must first be considered with reference to the amount of glue that will be absorbed—whether the surfaces shall be "sized" to fill the pores, and if so, to what extent; also what the consistency of the "sizing" shall be. The natural temperature and consistency of the glue and the amount to be laid on, are all questions involving nice discrimination. The veneers themselves must also be considered. Some kinds of wood, such as American walnut, will not permit of dampening or steaming unless there is quite a regularity of fibre. The veneers known as crotch wood (from the forks of trees) in which the grain is disposed at all angles in the same piece, has to be laid without dampening, or it will crack when dry; but plain wood, such as rosewood, motley wood, or bird's-eye, can be dampened, which greatly facilitates the process of laying. In this country, previous to the employment of machinery, and when furniture was made by hand, veneers were laid by "cauls," and hand-screws, or "rubbed on," the first plan being adopted for all surfaces of any considerable size, while the narrow bands of two inches or less in width were rubbed on. The caul is simply a thin board coated with beeswax, to prevent the adhesion of glue; it is heated and placed between successive layers of veneered pieces, communicating its heat through the veneers and melting the glue, when the whole is compressed with screws. A very common error in laying veneers with cauls, is to use the glue too hot, or to warm the stuff to be veneered, which requires just the opposite treatment to that of the caul; to be kept cool and allow the glue to chill as soon as possible, this prevents evaporation of the water from the glue, which, when again melted by the hot caul, returns to the same condition in which it left the glue pot.

It is best when practicable to expose the glue surface to the cold air, even in winter, as fast as the glue is laid on, and while the cauls

are being prepared. The rubbing process requires no little dexterity, and in the shops is considered a good test of the workman's abilities, the veneers being cut into strips and jointed, the wood surface being sized, dried and scraped.

The veneer is wet on the outside with a sponge dipped in hot water; the glue, which must be very thick and hot, is then hastily applied to the other side; the veneers then placed and rubbed down with the "pane" of the veneer-hammer before the "glue sets," the whole requiring the greatest dexterity and skill.

The writer of this article does not in his mechanical experience remember anything that was approached with the same trepidation as the first attempt to rub down veneers.

Veneers are manufactured by sawing and by cutting. The sawed veneers, being the best, command a much higher price in the market, a distinction that would be necessary even if the quality was the same, the "waste" being greater than the "product." Thirty-five to the inch is a common gauge for sawed veneers of mahogany, the saw kerf being nearly twice as much.

In cutting or shaving veneers with a knife there is but little waste; the wood is, however, somewhat fractured by the cutter, which must of necessity have an obtuse angle at its edge to secure strength.

We present in this number, engravings of two veneer cutting machines, as manufactured by Messrs. Ransome & Co., of London, England.

Fig. 1 is a sawing machine in true side elevation, $\frac{1}{2}'' = 1'$. The log is fastened to the frame or carriage seen in the fore ground, and is automatically fed to the saw by means of screws that regulate the thickness, which, as a minimum, is thirteen to the inch, including kerf.

The saws are made from eight to fourteen feet diameter, the weight of the machines being from six to twelve tons. The saws make from one to two hundred revolutions per minute.

The peculiarity of veneer sawing mills is entirely with the saw, which consist generally of a cast iron disc turned up with great truth. The saws, which are in sections, are riveted to the periphery, and are ground off to a very thin edge; the veneer, being thin and flexible, bends outward to accommodate this wedge-form of the saw and cast-iron disc, obviating the necessity of setting the saw and facilitating the cutting by giving clearance for the dust and plate.

Fig. 2 is a side view, on the same scale, of a veneer slicing or cutting machine, by the same makers.

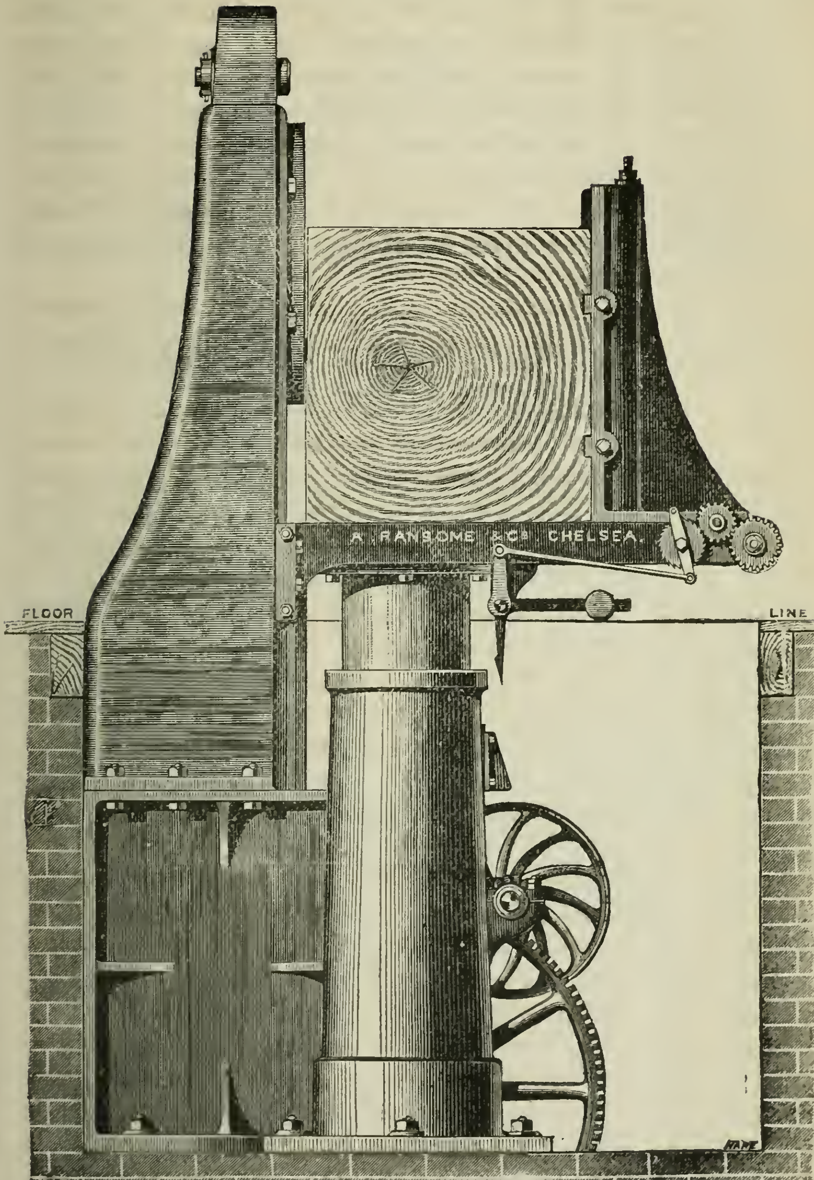


Fig. 2.

The knife is stationary, supported by the strong column on the right; the platen on which the wood is mounted has a reciprocating vertical movement to correspond with the depth of the "stick," which

is fed up at each stroke by means of the pawl and bellcranks shown. It has a capacity of cutting one hundred to one hundred and forty superficial feet per minute. Weight eight tons.

Cutting and slicing wood from steamed or wet blocks is in England quite an old art, introduced no doubt by the higher price and consequent economy in wood cutting.

It was applied not only to veneers but to preparing stuff for boxes, roofing-shingles, in fact, to the manufacture of all kinds of thin stuff of limited dimensions.

PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Joseph M. Wilson, C. E.

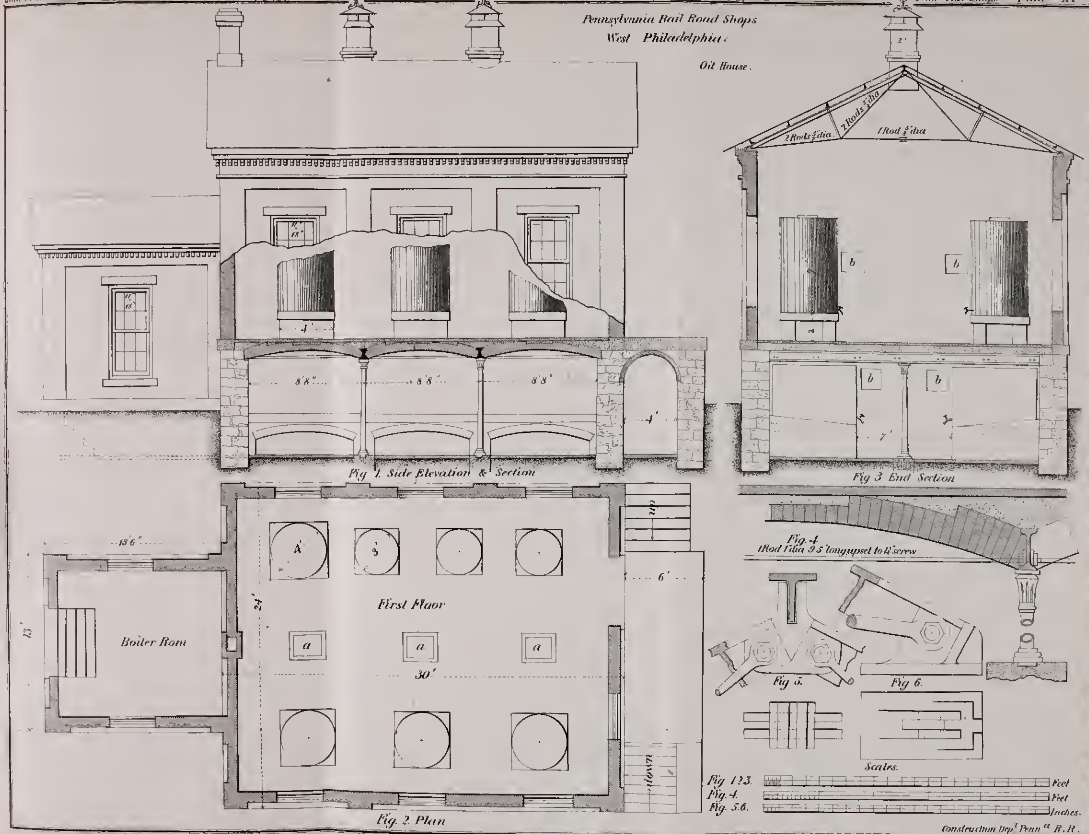
P. A. Engineer Construction Department Pennsylvania Railroad.

(Continued from page 114.)

Oil House. The location of this building is shown by reference to Plate I, where it is marked No. 5. It is intended for the storage of oil for use in the shops, and is designed as a fire-proof structure throughout, no combustible material being used in the construction of any part of it. As will be seen by the plan, Plate XI, it consists of a main portion 24 feet by 30 feet, outside measurement, with a boiler room at the back 13 feet 6 inches by 13 feet, and a platform in front 6 feet wide by 14 feet long. A railroad track runs in front of the building, and the level of the top of platform is made 4 feet above the top of rails of track, a convenient height for loading and unloading oil from cars, and our standard height of platform for warehouses.

The main building is divided into a first floor and basement, the latter having an outside entrance under the front platform, wide enough to admit barrels of oil. The foundations and walls, up to the level of the first floor, are of stone finished off with a cut stone belting course, the front platform being of stone also.

Above the first floor the walls are of brick 9 inches thick, with pilasters 13 inches. The basement floor is of brick laid in cement and having drainage into a sewer. On each side of a passage way 7 feet wide, low platforms of brick are built on flat brick arches, for the support of oil tanks. The first floor is supported through the centre by two cast iron columns sustaining wrought iron I beams, from which spring flat brick arches. The cast columns are of $\frac{1}{2}$ inch metal, 3 inches external diameter at the top and 4 inches at the bottom, and rest upon firm stone foundations. The wrought iron I beams are



Jas M^c Guigan Lith Phila

9 inches deep, weighing 89 pounds to the yard, and they are connected together, and also to 4-inch angle irons on the end walls, at distances of 3 feet apart in their lengths, by iron rods 1 inch in diameter, these rods taking and counteracting the thrust of the brick arches which spring from the I beams and angle irons. On top, the arches are leveled off with concrete and paved with brick, thus forming the first floor. Fig. 4, Plate XI gives the details of these arches.

Brick piers supporting stone slabs, are built on the first floor in the positions shown on plan, for the support of oil tanks, the top surface of stone being 2 feet above the floor. The basement is lighted by openings in the crown of each arch of the ceiling, marked *a*, in the plan, and filled with hammered glass 1 inch thick. The first floor has ample light from seven windows, the frames and sash of which are of cast iron, and outside shutters of wrought iron. The doors are of wrought iron, with frames of cast iron. The roof is a simple wrought iron truss, the rafter being $3\frac{1}{2}$ by $3\frac{1}{2}$-inch T iron, the ridge pole of the same, and the purlines of 3-inch angle iron. The number and sizes of the tie rods are given on the Plate, and Figs. 5 and 6 show details of head and heel blocks, which are of cast iron. A covering of corrugated galvanized iron, with two large ventilators to carry off the disagreeable odors of the oil, completes the building.

To provide light at night and to prevent taking any fire into the oil rooms, four small windows, one light each, 18 inches square, of heavy glass set permanently into an iron frame, are built into the wall between the main portion of the building and the boiler room, see *b* on Plate, and a gas burner is placed before each window on the boiler room side, so as to shine into the main building when lighted. Vertical pieces of 4-inch cast iron pipe are built in the arches of the first floor over openings in each tank of the basement, to allow basement tanks to be easily filled from the oil room above, and also to afford facilities for the introduction of pumps to transfer the oil from these tanks to tanks on the first floor.

The boiler room is provided with a small vertical boiler, working at a low pressure (only the ordinary pressure in the service water pipes) and having coils of steam pipe in the basement and on first floor for warming in winter.

The basement tanks are rectangular in form, with an inclined bottom, being so made that any sediment may collect in front and be easily removed, when necessary, through an opening provided for the purpose. There are three of these tanks on one side and four on the

other, the large tanks holding 1739 gallons, one smaller one 1618 gallons, and the remaining three 1130 gallons each. On the first floor are four large tanks, cylindrical in form, of 642 gallons each, and three smaller tanks of 361 gallons each. The total capacity of tanks is 13876 gallons, or 385½ barrels. The tanks are constructed of boiler iron. Should it be needed, a mixer can easily be put up on the first floor, and be heated by a steam coil from the boiler. The mixing, however, is now done at Altoona oil house, a larger building than this, but constructed upon the same general plan.

(To be continued.)

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 91.)

"Good new belt leather has been found to break with an average tension of 5000 lbs. applied quietly per square inch of sectional area.

"The working tension for continuous service ought not to be more than about one-fourteenth of this, or about 350 lbs. per square inch.

"A thickness of three-sixteenths of an inch, which is the ordinary thickness, equals ·186 inch; therefore, for an inch of breadth we have $\cdot186 \times 5000 = 930$ lbs. breaking strain, and $\cdot186 \times 350 = 65\cdot1$ lbs. continuous service strain.

"With the same working tension, when we double the breadth, we reduce the strain per square inch of section to one-half the strain for the single breadth, and thereby save the belt. The axle pressure is the same, however, because the belt of double breadth is simply doing the same amount of work upon the rim of the pulley as the single breadth had to perform.

"When we double the diameter, the revolutions of pulley per minute being as before, we may reduce the tension to one-half; because we have the speed at the circumference equal to 2, and this multiplied by ·5 tension = 1 power; the same as 1 speed × 1 tension = 1 power.

"When two pulleys at rest are connected by a belt the tension on each connecting part is nearly equal; when motion begins, the driving pulley has to stretch the pulling parts to the tension required to overcome the resistance before the driven or loaded pulley can move; and, in doing so, the driver is passing a corresponding amount of slack into the returning part.

"Should the resistance of the load grow less from any cause, less tension will be required to balance it, and the driven pulley will be moved by the excess of the pulling tension a fractional quantity faster than the driver, thereby throwing part of the slack of the returning part into the pulling part, until the reduced load resistance and the pulling tension come to a balance; this diminishes the amount of slack on the returning part.

"On the other hand, should the load increase from any cause, greater tension is required; the driver must move a fractional quantity more than the loaded pulley to put the greater strain upon the belt, and the amount of slack is increased correspondingly.

"Hence, in a narrow belt, the returning part will be slacker than when a broader belt is employed, because it will stretch more with a given tension.

"Short belts require to be tighter than long ones. A long belt, working horizontally, increases the tension by its own weight, acting in the curve formed between the pulleys.

"One of the properties of this curve is to make the tension greater than is due to the simple weight of the belt; that is greater than when the belt is hanging vertically; besides it never loses contact.

"In vertical belts so little stretch is needed to make them lose contact with the lower pulley, that the tension for the state of rest requires to be greater than is found necessary for a horizontal belt, if the breadth be not increased to reduce the stretching stress per sectional square inch.

"In ordinary leather belts, on large pulleys, the bending resistance is so small that it may be disregarded.

"Ropes of hemp or wire are often employed for driving bands. Their resistance to bending is greater than that of flat leather belts, and as the surface in contact with the pulling is less, the pressure per square inch of actual contact must be greater, and therefore more severe upon the material.

"This, however, does not affect the amount of tension required for work, because, as friction is independent of the extent of surface, we get the same driving power from 10 lbs. pressure or tension on the narrow line of contact with the pulley in the case of a circular rope, that we would get from the same pressure supposing the rope flattened out so as to have a surface of contact many times greater.

"When we know the weight per foot of a long belt or rope working horizontally, we find the tension in the curve of the belt between

the pulleys by multiplying the whole weight of the part between the pulleys by the distance between the same and dividing by eight times the deflexion. This rule, however, applies only to curves in which the deflexion is small compared with the span; so that the flatter the angle of suspension the closer the approximation."—*Power in Motion.* By J. Armour, C. E. Lockwood & Co., London, 1871.

Mr. C. R. Rossman, in the *Technologist* for Oct., 1871, gives 45 lbs. per inch of width as the safe working tension of single leather belts, and presents the following data: A 125 horse engine drives two 18-inch belts over 8-foot pulleys, making 75 revolutions per minute. This gives a velocity of 1875 feet per minute, and a tension of 61 lbs. to the inch of belt.

"This is in excess of the safe limit of tension generally recommended; but we may here remark that belts of the width here mentioned are generally thicker and stronger than the average belts used, and from which the ordinary data were taken. But, from a careful examination of a great number of cases of belts of ordinary width and strength, we find that a safe and judicious limit lies between 40 and 50 lbs. In order to increase this, however, it is not unusual for engineers to double the thickness of the belt by cementing or rivetting two thicknesses of leather together. But this plan, though advisable in some cases, is not so economical of power and material as the equally efficient plan of increasing the width of the belt."

"The tensile strength of good ox-hide, well tanned, has been carefully examined, with the following results:

The solid leather will sustain,	per inch	of	width,	675 lbs.
At the rivet holes of the splices	"	"	"	382 "
At the lacing	"	"	"	210 "
Safe working tension	"	"	"	45 "

The belts are assumed to be one-fifth of an inch thick."

ON THE FLOW OF WATER IN RIVERS AND CANALS.

By J. Farrand Henry, Ph. B.

(Continued from page 262.)

At the surface and five feet below, the floats give a less velocity than the meter; a light wind was blowing up stream at the time, which would probably retard the floats a little. Below this point, the floats show a greater velocity than the meter, constantly increasing towards the bottom. Making the difference at the surface zero, a

slightly curved line will pass through nearly all the points of difference. The ordinates of this line are given in the last column of the table, headed "Corrected Difference." The observed differences and this curve are plotted in Plate II, figure 6.

TABLE V.

No. of Observations.	Wind, parallel to the direction of the river, in miles per hour.	Depth of observation below the surface.	Velocity of Current in feet per second.			Corrected Difference.
			By Floats.	By Meter.	Difference.	
50	3·26 up	1 ft.	3·619	3·655	—0·036	
62	1·92 "	5 "	3·759	3.783	—0·024	0·030
56	1·27 "	10 "	3 703	3·674	+0·029	0·070
50	0·48 "	15 "	3·590	3·516	+0·074	0·120
54	0·29 down	20 "	3·598	3·405	+0·193	0·170
31	0·53 up	25 "	3·637	3·441	+0·196	0 240
37	0·80 "	30 "	3·546	3·279	+0·267	0·320
29	2·18 down	35 "	3·556	3·166	+0·390	0·400
12	4·85 "	40 "	3·636	3·142	+0·494	0·490
7	0·74 up	45 "	3·542	2·985	+0·557	0·600

1ST. THE ERROR OF CROSS SECTION.

In order to ascertain the true mean area, it would be necessary to know the exact depth of the river past the whole base line. Generally it is considered sufficient to sound out two or three lines across the river, and take their mean. But when the bottom is not perfectly regular, this may differ considerably from the true mean depth. It is claimed that one reason why so short a base was chosen in the Mississippi observations, was that the eddies, whorls, and common irregularities of the current, past a long base, vitiated the results; and Mr. S. F. Abbert, who made some current observations with double floats on the Arkansas River in 1869, shortened his base to 100 feet, because he found too much irregularity in 200. Then, if the base is reduced to zero, all errors from this cause must disappear, which is precisely what is done when meter observations are made.

However, on Gen. Abbert's suggestion, this matter was tested on the St. Clair River. The base was divided into three nearly equal parts, and floats were located and timed past each section.

It was found that, though individual floats varied greatly, the mean velocity in each section was about the same as the mean velocity past the whole base.

2D. THE PULSATION OF THE CURRENT.

This is, perhaps, the most curious phenomenon of flowing water

All water in motion, from the jet of a toy fountain to the Gulf stream, has an intermittent velocity, increasing and diminishing in accordance with some yet undiscovered law. This fact has been known for a long time; but without some such apparatus as the telegraphic meter, the amount and duration of these pulsations, especially below the surface, could not be measured. With this meter, however, by placing a Morse's paper register or, better, a chronograph in the circuit, every revolution of the wheel can be recorded on the moving paper, and thus every change in the velocity of the current noted.

Although these pulsations were found in every stream that was tried, from the slow-moving St. Lawrence to the tail race of a mill, no general law of variation has yet been deduced, and we can only say that the lesser fluctuations are from half a minute to a minute in duration, with larger ones every five or ten minutes.

They do not seem to be synchronous with the oscillations of the surface level, which are also very irregular, and attain their maximum fully as often during the increase as the decrease of the velocity.

Nor can M. Bazin's supposition be correct, that they are due to eddies and whorls of the surface current, as they are much smaller at the surface than toward the bottom. In fact, as near the bottom as measurements could be made, the velocity was sometimes less than half what it was at its maximum.

Capt. Boileau, speaking of the belief of Dubuat and other engineers of the adherence of the fluid molecules in contact with the bottom, says:* "But it would seem more rational, and more in accordance with experiments, to consider the bottom and sides as forming by their asperities eddies, which consume nearly all the work of the motive forces, so as to leave the force of translation very weak. On the other hand, we know that each eddy formed in a fluid current causes, by the lateral communication of its movement, a second, of greater size but with less force of rotation, and this gives birth to a third, still more feeble, and so on until these gyratory movements become insensible."

The formation of ridges in the sand at the bottom of canals, as shown by Dubuat's experiments, in precisely the same manner as the sand dunes are formed by a pulsating wind, would seem to indicate also the existence of such eddies at the bottom, which would of course

* Traité de la mesure des eaux courantes. Par P. Boileau. Paris, 1854. Page 339.

produce variations in the velocity of the current, decreasing towards the surface, just as the observations show is the case with those pulsations.

But, whatever theory be accepted as to their cause, it is easy to see that they must greatly affect the velocity obtained from floats, particularly as we approach the bottom.

Often, when two floats were put out from the upper boat, one minute apart, the last one would gain upon and sometimes even pass the first. As 150 floats is a good day's work, if we assume that each float is one second in passing the centre foot of the base line where the mean area is taken, the velocity will have been actually measured for only 150 seconds during the day, and the mean would be greater or less than the true mean velocity, according as the majority of the floats had passed during the increase or decrease of the pulsations.

3D. The Uncertainty of Location.

Even when the base line was one-third the width of the river, and the stations connected by telegraph, it was found almost impossible to locate the exact point where the float crossed the section lines. As the velocity is slower near the banks, the measured velocity would be too small or too large, as the location was on one side or the other of the true place of the float. Moreover, the floats rarely ran parallel to each other, or in the same vertical plane.

Often, in still weather, when the upper boat was in the center of one of the 200 feet divisions (into which the rivers were divided by imaginary lines for convenience in reduction), part of the floats would run entirely out of the division, or more than 100 feet out of their proper plane. The calculated path of the float was sometimes more than half a foot in a hundred longer than the distance between the section lines.

4th. Floating Bodies Move Faster than the Water in which they are Immersed.

This error is very small compared with the others, and the formula for its computation has already been given.

5th. The Upper Float Drags the Lower.

This error is also small, and depends upon the relative size of the floats and the velocity of the current.

6TH. THE EFFECT OF THE CURRENT ON THE CONNECTING CORD.

The cord used in the Mississippi observations was from one to two-tenths of an inch in diameter. It has a tendency to drag the lower float; but, what is of more importance, it can never be perfectly straight, but curves down stream, and therefore raises the lower float. This brings the float into a faster current, and thus gives much too large velocities, especially when the depth is considerable.

When starting the floats from the upper boat, both cannot be thrown out together without danger of entangling the cord; but the upper must be held until the lower has gone far enough to extend the cord. The upper float must then move enough faster than the lower to assume its proper position before they reach the upper section line, otherwise it will pass the base with nearly the full velocity of the surface current, instead of being retarded by the lower float. Whether this actually takes place cannot be known; and the distance required for the two floats to assume their proper relative positions will depend on the length of the connecting cord and their velocity.

When the floats are in their proper relative position one cannot be vertically over the other, but the cord must form a curve, whose chord is the hypothenuse of a right-angled triangle, the perpendicular being the actual depth of the lower float, and the base varying according to the depth, velocity and relative size of the floats and the length and size of the connecting cord.

Of these errors the first three are uncertain, and the last three are always plus; but the sixth is the most important, as well as the most difficult to eliminate. It is, however, evident that these errors must increase with the depth, as the comparisons given in Table V show, the lowest observation giving the error of floats over half a foot per second. This correction would only apply to float observations in a river of the same depth and velocity as the St. Clair. In the St. Lawrence, with a current of only about one mile an hour, it is much less. In the deep and swift-flowing Mississippi it must be much greater. The discharge, computed from the meter observations, was about ten per cent. less than that obtained from the floats; and we may therefore call the co-efficient of double floats, when observed past a long base, 0·9. When a shorter base is used, the errors of observation would probably somewhat decrease this co-efficient.

MAXIMUM VELOCITY.

About the year 1730 Pitot invented the tube which has since borne

Table VI.

Series.	Form of Canal.	Character of Bottom.	Width.	Depth.	Ratio of Depth to Width.	Mean Velocity.	Depth of maximum Velocity below surface.
			Meters.	Meters.		Meters.	
59—1	Rectangular	Plank	1·988	0·084	0·04	1·207	
62—1	"	Strips 0·01 m. apart	1·988	0·109	0·05	0·961	
59—2	"	"	1·994	0·134	0·07	1·573	
65—1	"	" 0·05 m. apart	1·992	0·135	0·07	0·756	
58—1	"	Plank	1·998	0·138	0·07	0·730	
63—1	"	" 0·01 m. apart	"	0·144	0·07	1·454	
62—2	"	"	"	0·158	0·08	1·336	
61—1	"	"	"	0·160	0·08	0·643	
60—1	"	Plank	1·994	0·180	0·09	2·297	
59—3	"	"	"	0·201	0·10	2·501	
65—2	"	" 0·05 m. apart	1·992	0·207	0·10	1·000	
58—2	"	Plank	1·998	0·215	0·11	0·953	
63—2	"	" 0·01 m. apart	"	0·218	0·11	1·925	
61—2	"	Plank	"	0·244	0·12	0·854	
62—3	"	" 0·01 m. apart	"	0·248	0·12	1·702	
68—1	Trapezoidal	Plank	1·500	0·191	0·13	0·908	
69—1	"	"	1·048	0·133	0·13	0·406	
59—4	Rectangular	"	1·984	0·265	0·13	2·318	
67—1	"	" 0·05 m. apart	0·800	0·110	0·14	1·084	
63—3	"	" 0·01 m. apart	1·988	0·286	0·14	2·199	
66—1	"	" 0·05 m. apart	1·994	0·288	0·14	1·464	
55—1	"	Cement	1.812	0·269	0·15	2·509	
65—3	"	" 0·05 m. apart	1·992	0·322	0·16	1·295	
62—4	"	" 0·01 m. apart	1·998	0·320	0·16	1·979	
58—3	"	Plank	"	0·332	0·17	1·248	
61—3	"	" 0·01 m. apart	"	0·377	0·19	1·109	
66—2	"	" 0·05 m. apart	1·994	0·380	0·19	1·675	
68—2	Trapezoidal	Plank	1·580	0·300	0·19	1·188	
69—2	"	"	1·148	0·221	0·20	1·771	
58—4	Rectangular	"	1·988	0·436	0·22	1·429	0·030
65—4	"	" 0·05 m. apart	1·992	0·412	0·22	1·511	0·130
69—3	Trapezoidal	Plank	1·208	0·275	0·23	1·992	
68—3	"	"	1·800	0·433	0·24	1·329	
64—1	Rectangular	" 0·01 m. apart	1·988	0·487	0·24	0·856	0·157
56—1	"	Gravel	1·832	0·394	0·24	1·714	
57—1	"	Small stones	1·860	0·452	0·25	1·471	0·050
61—4	"	" 0·01 m. apart	1·988	0·495	0·25	1·267	0·155
73—1	Semicircular	Plank	1·100	0·270	0·25	0·966	
71—1	"	Cement	1·000	0·268	0·27	1·052	
69—4	Trapezoidal	Plank	1·281	0·342	0·27	2·156	
68—4	"	"	1·984	0·546	0·27	1·497	0·190
72—1	Semicircular	Fine Sand	1·000	0·292	0·29	0·954	
69—5	Trapezoidal	Plank	1·348	0·393	0·30	2·281	
73—2	Semicircular	"	1·260	0·377	0·30	1·230	
74—1	"	Small stones	1·080	0·322	0·31	0·825	
69—6	Trapezoidal	Plank	1·398	0·430	0·31	2·385	0·130
64—2	Rectangular	" 0·01 m. apart	1.988	0·660	0·33	0·948	0·230
71—2	Semicircular	Cement	1·160	0·378	0·33	1·300	
72—2	"	Fine sand	1·165	0·388	0·33	1·266	
71—3	"	Cement	1·180	0·456	0·39	1·534	
74—2	"	Gravel	1·170	0·458	0·39	1·028	0·120
73—3	"	Plank	1·300	0·554	0·41	1·450	0·110
72—3	"	Fine sand	1·190	0·488	0·41	1·392	
71—4	"	Cement	1·200	0·528	0·44	1·676	

TABLE VI.—*Continued.*

Series.	Form of Canal.	Character of Bottom.	Width.	Depth.	Ratio of Depth to Width.	Mean Vecocity.	Depth of maximum Velocity below surface.
			Meters	Meters.		Meters.	
72—4	Semicircular	Fine sand	1·210	0·554	0 46	1·569	
74—3	"	Gravel	1·200	0·567	0·47	1·162	0·160
70—1	Triangular	Plank	0·800	0·380	0·47	1·406	
71—5	Semicircular	Cement	1·225	0·588	0·48	1·782	
70—5	Rectangular	Plank	1·400	0·686	0 49	2·218	0·130
70—3	"	"	1 160	0·570	0·49	1·922	0·130
70—2	Triangular	"	0 980	0·480	0·49	1·719	0·130
70—6	"	"	1·480	0·735	0·49	2·294	0·130
71—2	Semicircular	Cement	1·250	0·625	0 50	1·786	0 100
73—4	"	Plank	1·400	0·704	0·50	1·162	0·050
74—4	"	Small stones	1·220	0·610	0·50	1·229	0·200
70—4	Triangular	Plank	1·260	0·630	0·50	2 084	0 130
71—8	Semicircular	Cement	1·250	0·632	0·51	1·810	
71—7	"	"	"	0 662	0·53	1·786	
72—5	"	Fine sand	"	"	0·53	1·679	0·050
67—3	Rectangular	Plank	0·800	0·486	0·61	1·860	0·156

SMALL FEEDERS IN MASONRY.

75—1	Trapezoidal	Masonry	1·201	0·150	0·13	1·824	
75—2	"	"	1·203	0·234	0·19	2 352	
75—3	"	"	1·204	0·291	0·24	2·560	
75—4	"	"	2·750	0·464	0·29	2·707	
76—1	Irregular Trapezoid	"	2·750	0·464	0·16	0·266	
76—2	"	"	3 000	0·623	0·21	0·391	0·303
76—3	"	"	3·200	0·746	0·23	0·461	0·453
76—4	"	"	3·400	0·835	0·25	0·513	0·400
77—1	"	"	1·996	0·663	0·33	0·253	0·203
77—2	"	"	2·060	0·853	0·42	0·413	0·500
77—3	"	"	2·080	0·987	0·47	0·501	0·500
77—4	"	"	2·100	1·135	0·54	0·638	0·650

his name, and made the first actual measurements of the subsurface velocity of water in canals. Before that time many engineers held, with Castelli, that the velocity of the molecules of water increased directly as the depth, while others, following Guglielmini, believed the increase was the square of the depth. None doubted, however, that the maximum velocity was at the bottom, although Papin warned his contemporaries against attempting to apply to fluids Galileo's laws for the friction of solid bodies.

Pitot's experiments proved that the velocity in canals increased for a certain distance below the surface, and then decreased toward the bottom.

Since his time many observations have been made to determine the law of variation in the velocity, with apparently very diverse results. Most of these observations were made on small canals, and in them the maximum velocity was found considerably below the surface; while in the few European rivers and streams which have been gauged, it was at or near the surface. The latest velocity observations on canals are those made by MM. Darcy and Bazin; and, as they give their observations in detail, we can readily find the *locus* of maximum velocity. Table VI is compiled from their observations.* It shows the kind of canal used, the nature of the bottom, the width and depth of the water, the ratio of the width to the depth, and the distance below the surface of the maximum velocity of the center vertical.

The descent of the maximum velocity in these observations does not seem to depend on the velocity, but upon the ratio of the depth to width, and somewhat upon the character of the bed. Thus, in rectangular canals the maximum of the center vertical remains at the surface until the depth is about one-fourth the width; but when the depth is half the width it descends to about one-third the depth below the surface.

In triangular canals, on the other hand, the surface velocity is the greatest until the depth is about one-third the width; and when this ratio is one-half, the maximum is only about one-fifth the depth below the surface.

In the trapezoidal and semicircular canals, the portion of the sides enclosing the water is slanting until its depth is about one-half the actual depth of the canal; then it becomes vertical, or nearly so; so that below that point the effect is the same as in the triangular, and above it, the same as in the rectangular canals.

* Récherches Hydrauliques, page 187 *et seq.*

The nature of the bed seems to have an influence upon the descent of the maximum velocity, for when the lining of the canal was rough the table shows it to be somewhat deeper than when the lining was smooth.

This table only gives the *locus* of the maximum velocity of the center vertical. In the rectangular canals it is often found at mid depth near the sides, even when the ratio of depth to width is small enough to carry it to the surface on the center vertical. Thus, lines drawn through the points of equal velocity follow nearly parallel to the bottom and sides of the retangular canals, until about mid depth, when they bend inwards toward the center, as if forced off from the upper portion of the vertical sides.

In the canals of other forms this effect is not so marked, and in the triangular is scarcely noticeable.

M. Bazin remarks that the friction of the air has certainly much less influence in retarding the upper layers of the water than this curious and unexplained influence of the sides.

(To be continued.)

New Illuminating Devices.—Mr. R. Brown has devised a safety-lamp especially adapted for giving increased illumination over the ordinary forms. The lower part of the wire-gauze cage is furnished with a plano-convex lens, which is surrounded by a cone of tin plate, which serves to protect the glass and increase the reflection. The light is additionally increased by the use of a reflector behind the flame.

Mr. T. E. Rome has likewise invented a signal-lamp, which shall relight itself automically (a Relume signal-lamp). The construction, which is ingenious, is as follows: A compound rod or bar—composed of two metal strips of different co-efficients of expansion is fixed above the flame and a catch attached to the end of the bar is held in place while the lamp is burning. So soon as the lamp is extinguished, the bar, which is bent or curved by the unequal expansion of its two sides from the heat of the flame, begins to cool and to straighten. When quite straight the catch is removed, liberating a spring which causes some matches to be ignited and to light a second wick.

Mechanics, Physics and Chemistry.

THE CHEMICAL THEORY OF THE VOLTAIC BATTERY.

By Joseph P. Cooke, Jr.

MOLECULES AND ATOMS.

1. *Fundamental Laws.*—Within the last ten years two important principles have become almost universally recognized as fundamental laws of chemistry. These are:

First, that *The molecules of matter, when in the state of gas, and under like conditions of temperature and pressure, occupy in all cases the same volume.*

Secondly, that *The atoms of matter have different degrees of quantivalence, measured by the rate at which they replace or combine with each other.*

2. *Molecules.*—Molecules are the smallest particles of any substance which can exist of themselves, and the first law enables us to estimate their relative weight. For, if equal volumes of all substances (under the conditions named) contain the same number of molecules, it is obvious that the weights of the molecules must be in every case proportional to the weights of the equal gas volumes of the substances compared; or, in other words, proportional to the specific gravities of these substances in the state of gas. Hence, if we selected hydrogen—the lightest gas—as the standard of specific gravity, and the hydrogen molecule—the lightest molecule—as the standard of molecular weight, the number which expresses the specific gravity of any gas would also express its molecular weight.

Our modern chemistry, however, while adopting hydrogen gas as the standard to which it refers the specific gravities of gases, has found it more convenient to take the half hydrogen molecule (the hydrogen atom) as the unit of molecular weight; so that the molecular weight of any substance, on this system, is equal to twice its specific gravity in state of gas, referred always to hydrogen gas as the standard.

The law we are considering is generally known in Germany as the Law of Avogadro, and it will be convenient to refer to it under this name; but it must be remembered that although we owe to Avogadro

the present form of statement, yet the fundamental facts on which the law is based were discovered by Gay-Lussac, and the principle itself distinctly enunciated by Ampére many years previously. The law of Avogadro is simply the law of Gay-Lussac, concerning the combination of gases by volume, as interpreted by the modern chemical philosophy.

If this law has been established, then the molecular weights are equally well-established facts of science, as fully so, for example, as the weights of the planets. These last are inferences from the law of gravitation, just as the molecular weights are inferences from the law of Avogadro. It is true that our knowledge of the molecular weights is limited to their relative values; but the same is almost equally true of our knowledge of the planetary weights. The earth is the standard to which the planetary weights are referred; and, while our knowledge of these weights in terms of the earth's mass is very accurate, it is only by indirect and, at best, approximate methods that we can refer this astronomical standard of weight to our ordinary units, the kilogramme or the pound. Nevertheless, although it would be highly satisfactory to know the exact weight of the planets in *pounds*, yet all the important purposes of astronomy are subserved so long as we know their weight in *earths*, the standard itself, from its very magnitude, being quite beyond the limits of our clear conceptions.

Now, the hydrogen atom, selected as the unit of molecular weights, is just as definite a mass of matter as the earth, and this chemical unit of weight lies no further beyond the range of our conceptions on the one side than does the astronomical unit on the other. Moreover, although we cannot be said to know the weight of this unit in fractions of a grain, the considerations advanced by Sir William Thompson, in a recent paper,* gives us reason to believe that the discovery of the relation between the two is at least within the range of possibilities. But, even if the constant required for reducing the molecular weights to their metrical values was known, it would add but little to our available knowledge in regard to them. Even in the ordinary affairs of life, we are always more concerned with relative than with absolute weights; and to how few persons does the term grain or gramme convey any definite conception of quantity.

A part of the vagueness of the conception which attaches to the

* American Journal of Science and Arts, July, 1870.

idea of molecular weight arises undoubtedly from the want of a specific name to designate the unit; and, since the word crith has already been used to denote the weight of one litre of hydrogen, I would propose to call the weight of one hydrogen atom (the chemical unit of weight) a microcrith. When we speak of the oxygen molecule as weighing 32 microcriths, this name will help to convey the impression that we are dealing with definite and measurable quantities.

It will undoubtedly be asked, how has the equality of the molecular volumes been proved? for, as we have seen, our knowledge of the molecular weights, and indeed the whole philosophy of modern chemistry, rests on the truth of this assumption. The question cannot be answered in a few words, for this great law of chemistry, like the law of gravitation, is an induction based on a great body of facts. It is true that, if certain postulates are granted, the law of Avogadro can be shown to be the necessary consequence;* but the proof of its validity is to be found rather in the circumstance that it not only coordinates the great body of known facts, but also is constantly leading to new discoveries. There are still discrepancies to be explained, but these are being one by one cleared up, and there can be no doubt that this law rests on as firm a basis to-day as did the law of gravitation for a half century after it was first enunciated by Newton.

3. *Atoms.*—Avogadro's law has not only given us clear conceptions in regard to the *molecules* of matter and their relations, but in connection with the doctrine of chemical quantivalence it has also led to an equally clear conception of the relations of *atoms*. *An atom*, as defined by modern chemistry, *is the smallest mass of an elementary substance that exists in any molecule.* Take, for example, the many volatile compounds of oxygen which are known. By determining their specific gravities in the state of gas, we can find the several weights of their respective molecules. In each case, by doubling the number expressing the specific gravity of the gas—referred to hydrogen—we obtain the weight of its molecule in microcriths. By chemical analysis we learn what proportion of the whole mass, and therefore what proportion of each of these molecules, is oxygen. Now, it appears that the smallest quantity of oxygen in the molecule of any known substance weighs 16 microcriths. Hence, 16 microcriths is

* See two remarkable papers on this very point, by Alex. Naumann and Karl Zöppritz, in the Annalen der Chemie und Pharmacie, vii, Supplement Band Seiten 339 and 348.

the weight of the oxygen atom. Further, it appears that a molecule of oxygen gas weighs 32 microcriths. The molecule of this elementary substance consists, therefore, of two atoms. We do not assert that this mass of matter we call the oxygen atom is indivisible, but, simply, that it has never been, to our knowledge, divided; or, in other words, that it is the smallest known mass of the elementary substance. Should we hereafter discover an oxygen compound whose molecule contained only 8 microcriths of the elementary substance, then the atomic weight of oxygen would be at once reduced to one-half of its present value.

It must be evident from what has been said that this conception of the atom involves no further assumption than the truth of Avogadro's law, and that the atomic weights are as definite values and rest on the same basis as the molecular weights.* But these legitimate inferences have been overlaid by a conception which, although very generally adopted by chemists, must be regarded as a pure hypothesis. We must necessarily view the molecules as isolated masses of matter, as much so as the planets, but according to this hypothesis the atoms are also distinct monads, pre-existing as such in the molecule, which is simply an aggregate of atoms. A chemical change consists, then, in the breaking up of the molecules, and the rearrangement of these parts, which merely shift their position, and retain their identity throughout all the molecular transformations. Those who hold this theory would expect, could they apply sufficient magnifying power, to see in each molecule of water, for example, three distinct particles, two of hydrogen and one of oxygen. Such an idea, however, is not a necessary part of the legitimate atomic theory, for it is certainly equally conceivable that the molecule of water would appear perfectly homogeneous, and that in the process of chemical decomposition the resulting oxygen and hydrogen molecules are evolved from the water by a much more subtile operation than the mere re-arranging of pre-existing particles. For it must be remembered that the various qualities which distinguish substances may depend, not on the essential nature of individual monads, but on divers affections superinduced on the same material substratum.

It is undoubtedly true that the common conception of the chemical

* For a further discussion of this subject, and other methods by which the molecular weights even of non-volatile substances may be frequently indirectly determined, see the author's work on Chemical Philosophy. Sever & Francis, Cambridge, 1869.

atom harmonizes with the only explanation we have as yet been able to give of a very large number of facts, and this is especially true of those phenomena which are to be considered in this paper; but we cannot be too careful in distinguishing between the legitimate inferences from established laws, and hypotheses, which, however convenient as aids to the attainment of general truths, that in their essense are still incomprehensible, must be regarded at the best as crude and mechanical ideals.

The atoms, then, of our modern chemistry, whether we regard them as pre-existing as such in the molecules, or as in some unknown way evolved from the molecules in the chemical process are real not ideal, magnitudes. They are quantities of matter, whose weight in microcriths is definitely known, and whose relations have been carefully studied. This study has led to the discovery of the law of quantivalence, the second of the two great laws enunciated above.

4. *Quantivalence.* According to the old chemical philosophy the atoms were equivalent, in the sense that they could replace each other, unit for unit, in a compound body. Hence on this system the atomic weights were the same numbers as the so-called chemical equivalents, and the two numbers were essentially synonymous. But when the atom is defined as above such is not the case, and the new philosophy distinguishes different orders of atoms, which it designates as univalent, bivalent, trivalent, quadrivalent, &c., according as they have the power of replacing one, two, three, four or more atoms of the lowest order, or an equivalent number of atoms of a higher order. Moroever the quantivalence of an atom measures not only its replacing but also its combining or "atom-fixing" power; for every atom can combine with or attach to itself as many atoms of either kind as it can replace, provided, of course, such combination is otherwise possible.

The doctrine of quantivalence opens at once the study of molecular structure, for on the multivalence of one or more of its atoms depends the stability of every complex molecule, and no molecule can exist as an integral unit unless its parts are all bound together by these atomic clamps. By studying the reactions by which molecules are formed or transformed, we have been able, in many cases, to discover the order in which the atoms are united in these microcosms, and the field of investigation thus opened is one of the most fruitful and most attractive which chemistry now presents. To those who have not carefully followed the progress of the work during the last

ten years, the results which are claimed may appear incredible, but, however great the skepticism in relation to the subject, any one who candidly and thoroughly examines the evidence can hardly fail to be convinced that the knowledge of molecular structure already reached is positive and real.*

As is well known, the atoms of many of the elements have different degrees of quantivalence, and it has been urged that this fact renders the whole doctrine indefinite and unsatisfactory. Now, it must be admitted, that with our present imperfect knowledge of the subject matter of chemistry, there is necessarily a certain amount of obscurity about all the generalizations of the science. But, without entering upon a detail of the facts on which the doctrine is based, and by which alone it can be justified, it is sufficient to say in reply to the above objection, that a change in the quantivalence of an atom implies not only a fundamental change in the qualities of the compounds into which it enters as a radical, but also a fundamental change in all the chemical relations of that radical itself. Such differences as those between the ferrous and ferric compounds of iron are familiar to every chemist, and the relations of the ferrous and ferric radicals, or of the manganese radical in the manganous salts and in the manganates, are as different as those of separate elements. Indeed, such radicals would be regarded as distinct elements, were it not for the single circumstance that they can be so readily transmuted, and it is by no means impossible that hereafter the distinction between the different radicals of the same element may be found to be as fundamental as that between the so-called elements themselves, and any one who studies the different relations of the elements in their various degrees of quantivalance, will be strongly impressed with this idea.

* It is frequently asked what advantage has the new philosophy of chemistry over the old, to compensate for the greater difficulties it presents to the learner. Those who ask this question, evidently believe that the philosophy of chemistry is an arbitrary system, and regard that system which is the easiest—in the school boy sense—as the best; but unless the most eminent chemists of the world have been following, during the last ten years, a mere phantom, it is evident that it is not less absurd to teach a system of chemistry which ignores the law of Avogadro and the doctrine of atomicities, than it would be to teach a system of astronomy, which should ignore the law of gravitation.

ON SOME IMPROVEMENTS IN THE REFLECTING TELESCOPE.

By J. A. Hill.

Read before the American Association for the Avdancement of Science, at Indianapolis, August, 1871.

It may not be amiss briefly to refer to a few points in the past history of reflecting telescopes, for the purpose of showing the gradual process of development which they have undergone, and the many obstacles which have presented themselves from time to time, in the efforts to increase the power and utility of such instruments; and also to show more clearly the relationship sustained by the plan which we now propose to the various others which have preceded it.

From the time that James Gregory and Sir Isaac Newton proposed the arrangements of mirrors and lenses, which have since borne their names, up to the present time, the success has indeed been most gratifying; as witness the marked improvements which have taken place under the direction of Short, Mudge, Edwards, Herschel, Rosse and others; the one or the other of these forms, or their various modifications, taking precedence in popular favor accordingly as they were adopted and improved from time to time by the ingenious men just mentioned.

But to the elder Herschel we are indebted for the production of the first telescope, which, passing all previous limits, were made of seven, ten, twenty, and finally of forty feet focal length.

Yet this latter instrument was liable to two important objections, viz.: 1st. The large and very heavy tribe to contain speculum, eye-piece, &c., requiring a very complex and unwieldy structure to give the proper support and motions to the tube, and also to enable the observer to follow the eye-piece from point to point, this being placed at the upper end of the tube in this construction; and 2d. The want of reflective power in the speculum. With the kind of mould then in use it was not possible to successfully cast specula, of true speculum metal, of any considerable size; hence the metal used in this large reflector was inferior in quality, having less reflective power and more liable to tarnish than that employed in the smaller and more perfect instruments.

Here then we find the limit was reached at that time in size, or rather should we not say was exceeded, considering the inferior quality of this monster telescope.

Your minds will now at once revert to the subsequent labors of

that ingenious nobleman the Earl of Rosse, one of the main results of whose numerous experiments was the construction of a mould, by means of which he cast successfully, and with comparative ease, mirrors of three and even six feet in diameter. These mirrors were composed of copper and tin united in their atomic proportions, which yielded, when ground and polished, a reflective surface of the most brilliant and permanent character. With some experience in the use of this mould, and taking into consideration the principles upon which it acts, I have no doubt that specula can be produced of any required size, with more certainty and far less trouble than was experienced in casting comparatively small ones on the old plan.

But when he came to mount for use his six-foot speculum, with a focal length of fifty-six feet, the speculum and box, together with the accompanying tube, weighing about fifteen tons, Lord Rosse found himself compelled to limit the motions greatly, there being only 15° of azimuth motion,thus largely diminishing its utility in various ways.

Still, although so circumscribed in motion, a necessity yet existed for an immense amount of mechanical appliances, such as walls, counterpoises, arcs, chains and windlass, moveable galleries, &c., &c., to direct the tube and enable the observer to follow it, this telescope, like Herschels', being built on the "Lee Maireau" or "front view" form; requiring the observer to be suspended in the air at a height of nearly sixty feet when looking at the zenith.

The plan suggested in this paper is an attempt to obviate this only remaining difficulty so far as construction is concerned, and to enable us to build telescopes without such limits, and of any required size, and which can be used with more of ease and comfort, no matter how large, than any yet made, either reflectors or refractors.

To accomplish this I propose to use two mirrors, operating substantially as shown in fig. 1. A represents a mirror circular in form, and ground on one surface to such concavity as to give the required focal length. B represents another mirror, oval in shape, and with the reflecting surface plane. The lesser diameter of this mirror should be equal to that of the concave one, and the larger diameter should be to the smaller as 5 or 6 to 4.

In the centre of this plane mirror is an oval hole, O, of such size as to allow the passage of the cone of rays thrown from the concave surface, D; the image being formed behind this oval mirror at K, and the eye-piece being applied as in the Gregorian and Cassegrainian styles.

The concave mirror is placed in a vertical position, so that the axis of said mirror shall coincide with a line running horizontally north and south, as c c in the figure. Opposite to this, and a little nearer to it than its focal length, is placed the oval mirror, which has two motions, one parallel to or coinciding with an imaginary axis, H H, passing through its lesser diameter, and the other about a hollow axis, placed at right angles to the former axis, and whose motion is made around the line c c as a centre. In this hollow axis the eye-piece is placed.

Parallel rays from an object, F, falling on to the plane mirror, B, will be reflected on to the concave surface, D, and from thence through the hole O in the plane mirror, forming an image at K which, being magnified by the eye-piece at S, will be seen by the eye at E.

Now, by moving the plane mirror around the line H H, it will be readily seen that any object from the zenith, M, to the horizon, N, may be viewed, and by moving it around the line c c running north and south any object between the eastern and western horizon may be viewed; thus embracing one-half of the visible heavens. These two motions correspond to the altitude and azimuth motions of other instruments. It will be observed that the eye remains in one position, looking in one direction all the time, wherever the object may be situated within those limits.

Now, by reversing the mirrors and looking in the direction of the same line, but in an opposite direction, the other half of the heavens can be seen.

To convert this instrument into an equatorial we have only to incline the mirrors, preserving their relative position, so that the imaginary line joining their centres shall be parallel to the axis of the earth, then by moving the oval speculum about this line as a centre, any siderial object can be followed by the one motion.

Fig. 2 represents a small instrument mounted as an equatorial. G is the stand or pedestal made of any suitable material, upon the top of which is fastened the bed-plate, R R, at a suitable inclination, by the bolts b b. At each end of this is an upright, S S, into which the axes of the telescope are laid. A is a shorter box with concave reflector; T is one of two bars fastened on to oppposite sides of box A. Between these bars at the opposite ends is placed the plane mirror B. Back of this the two bars are united by a cross piece, into which the hollow axis with eye-piece is placed. The mirror is fastened at any inclination by the thumb-screw 1. This is easily reversed by lifting it out of

its bearings; and when not in use may be kept in a suitable box; the stand and bed plate being permanently fixed in their positions. Fig. 3 shows an instrument of a larger size. At either end of the telescope a small room or observatory, A A, is seen, through the walls of which the hollow axis with the eye-piece passes, the observer being on the inside of the room. By means of suitable mechanical contrivances the proper motions are communicated from the inside to the mirror, C, thus enabling the astronomer to remain seated in *one* position, looking in *one* direction, and *entirely protected* from *cold*, *fatigue*, *night air*, &c. A very simple contrivance applied under the arms, T, will serve to sustain the weight, and also to reverse the instrument when required. This *telescope* also offers *unusual facilities* for *studying*, *drawing*, *mapping* or *photographing* the heavenly bodies. Any object which will admit of it may easily be photographed by darkening the room and placing a plate of the right size to receive the image properly prepared on a moveable screen, the size of the image being regulated by the distance from the eye-piece. This arrangement would enable *many persons to contemplate some of the celestial bodies*, such as the *sun*, *moon*, *&c.*, at the *same time*.

To construct an instrument on this plan of, say, 12 or 15 feet diameter and 150 or 200 feet focal length, let the ground be first levelled, and then the towers built at a suitable distance apart. Between these a double railroad track should be laid, the tracks running parallel to each other from north to south, and uniting in one curve at either end. The mirrors would be mounted separately on solid structures moveable on wheels, and thus would be easily reversible.

Differing as this does from all other constructions of telescopes, it will readily appear that a *great focal length is not objectionable*, it being as *easy to handle a mirror of* 1000 *feet focal length as one of the same size of* 50 *feet focus.*

To convert such an instrument into an equatorial select a piece of ground sloping to the south, grade to the exact inclination to give parallelism of the axis of telescope with that of the earth, the towers being built as usual if desired, and the mirrors mounted, the instrument may be used as an equatorial. Fig. 4 is a rough sketch of such an arrangement.

If it is desired to command a view of the whole heavens without reversing the mirrors in the usual manner, I would suggest that both

Fig. 1.

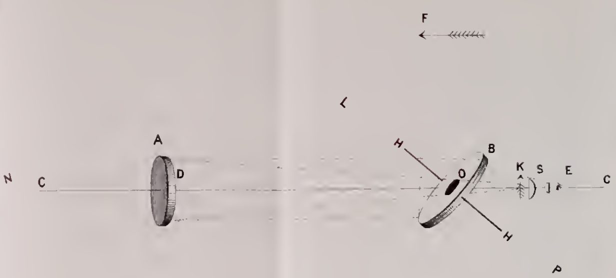


Fig. 2.

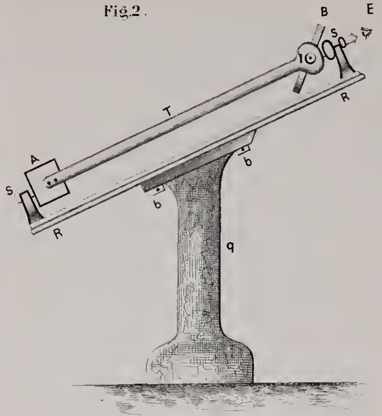
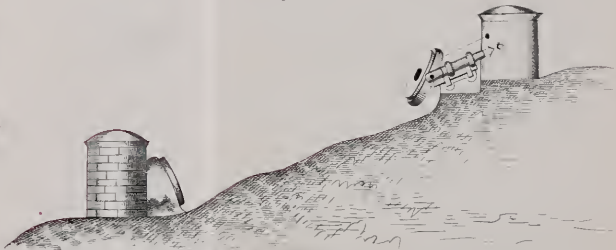


Fig. 3.

Fig. 4.



Jas McGuigan Lith. Phila

sides of each mirror be used alternately, one side of each being made plane and the other concave.

Thus the concave side of the lower mirror being used with the plane side of the upper one, commands the southern heavens from the northern tower, and the plane side of the lower one used with the concave side of the upper, commands the northern heavens from the southern tower. Both mirrors in this case must be perforated in the centre. The mirrors, in this instance, may be solidly fixed in their positions.

As it has not been thought necessary to enter into details, either as to the many forms this telescope may assume or to the great variety of mechanical devices for moving plane mirror or reversing the two mirrors, which would be adapted to those forms, a few words of comparison with other reflectors is all we shall add.

The tremor, so much complained of in some forms, having small specula supported on the ends of rods, or eye-pieces supported on the ends of long tubes, would be absent here, as the bearings are at each end, near the mirrors.

No tube is used for any size, but arms or bars connecting the specula may be used in the smaller sizes for convenience of handling, reversing, &c.

In illuminating power they are equal to all other telescopes having two mirrors, and inferior alone to the "front view" form, but superior to it in having no distortion of the image caused by inclining the mirror in that form, so as to throw the image to the side of the tube.

It is by far the simplest equatorial yet constructed, and the only one in which the line of sight, axis of instrument and axis of the earth all coincide. Clockwork may be added as in other equatorials, and a simple contrivance can be attached to the plane mirror, when the telescope is not in an equatorial position, which will give it a parallactic motion. This it is not necessary here to describe.

Simplicity of construction will enable these to be made much cheaper than others, especially if Faucault's plan of using glass mirrors be adopted.

One mould would answer for both mirrors, one side being convex and the other plane.

I am impressed that for any future enlargement of the boundaries of our observations we must look to the reflecting telescope, as it is impossible to construct refractors at all approaching the size which may be realized for mirrors.

The ratio of the illuminative power of a refractor and reflector of

equal aperture is usually considerod to be as 8 to 5. Still the Earl of Rosse succeeded in producing mirrors which were considered little, if any, inferior to an achromatic of equal aperture. The plane mirror might be made of blocks of speculum metal fastened on to a common basis and then ground and polished. Any slight deviation from a perfect figure would only cause a slight distortion, and not spherical aberration, as in the case of concave mirrors.

If telescopes. *far excelling in size and power* any yet made, shall be constructed, it is evident that the *enormous tubes*, with the *vast machinery to give the usual motions to those tubes must be dispensed with.* This arrangement of mirrors does that effectually, and it is doubted whether any other as simple can ever be devised, involving at the same time so many points of convenience and comfort in their use. The remaining difficulties of atmospheric inequalities, &c., are, of course, common to all instruments of any construction, and their discussion is not within the province of this paper.

CONTRIBUTIONS TO THE SUBJECT OF BINOCULAR VISION.

By Prof. Chas. F. Himes, Ph. D.

(Continued from page 270.)

THE STEREOGRAPH.—DIFFERENCE BETWEEN THE TWO PICTURES, AND HOW TO DRAW THEM.

It was noticed in our last that variation of the optic angle, or binocular parallax, independently of all other conditions within its proper limits, produces the impression of increase or diminution of distance, and enables us to perceive relief when the objects themselves are looked at. Before considering the nature of the connection existing between this variation of the optic angle and our ideas of distance, and some other kindred questions which are matters of dispute, it will be best to consider the methods by which the effect of solidity, as perceived by the two eyes when the object itself is observed, may be reproduced by means of flat drawings of the object.

Our two eyes, in affording us indisputable evidence of the relief of objects, have two different views of those objects; the images delineated on the two retinæ are different. If the head were retained in one position, and a drawing made of an object as seen with one eye open, and then one as seen with the other eye open, the drawings would differ as truly as any drawings of an object made from different points of view. But since the eyes are only on an average about two and a half inches apart, the difference would perhaps in most

cases not be apparent, except upon close inspection. It is allowable, therefore, to speak of right-eye and left-eye pictures.

A distinct comprehension of the nature of the difference between these pictures, lies at the foundation of a correct understanding of any discussion of the subject of binocular vision and the stereoscope, and in some of our best treatises its statement is frequently obscure or even incorrect.

A frustum of a cone has been selected for the illustration of this point, because, whilst it affords one of the simplest cases of a solid, it has all the advantages of a diagram of simple points. In fig. 5, R represents the right eye, L the left eye, A B C D a frustum of a cone. It will be sufficient to consider the four points A, B, C, D, in the section of the frustum made by a horizontal plane, passing through the eyes, and the diameters of the bases. The dotted lines represent lines in vertical planes. The line $a\ b'$ is the line of intersection of the horizontal and vertical planes. The lines from L and R to A, B, C, D, represent the optic axes, when these respective points of the frustum are distinctly seen, the eye, of course, being revolved with each change of point observed.

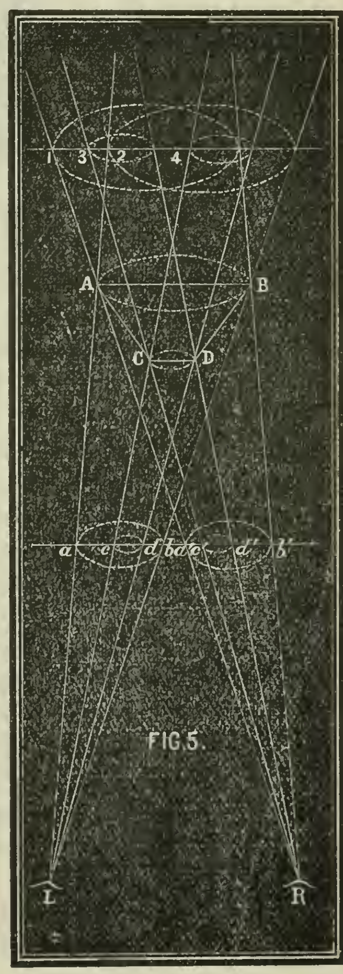


FIG. 5.

Suppose that a plate of glass be inserted vertically at $a\ b'$, it is evident, by inspection, that the four points A, B, C, D, as seen by the right eye, could be represented on the glass by points at a', c', d', b', or, in other words, that spots upon the glass at those points would completely hide the points A, B, C, D, and, as far as direction and distance are concerned, would produce the same impression on that eye. For the left eye $a\ b\ c\ d$ would answer the same purpose. If both eyes were open, according to

previous statements, these dots would be located in their proper positions, distance as well as direction would be observed. It is plain, that all the points in the bases of the frustum would have corresponding points on the glass plate, which would cover them, and that these points together would complete for each eye two circles, representing respectively the larger and smaller bases as seen by each eye, or that a diagram would be produced similar to fig. 6, in which L would be the picture of the frustum as drawn by the left eye, R as drawn by the right eye.

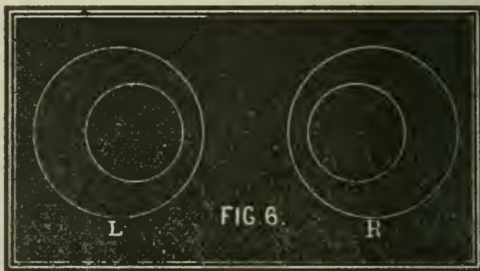


FIG 6.

A very perceptible difference is apparent here. It will be readily noticed that the small circle representing the nearer base is nearer the left edge of the larger circle, has its centre further to the left, in the picture, as seen by the right eye, and further to the right in that as seen by the left eye. The general rule may then be stated that, *in binocular pictures points nearer the observer—objects in the foreground—in the left-eye picture will appear further to the right than points more remote —objects in the background,—when compared with the same points, or objects, in the right-eye picture.*

Any stereograph, best not of a landscape, without marked foreground, because it lies in a great measure beyond the range of binocular effect, will verify this law. Objects in the foreground, in the left-eye picture, will be found to overlap, more to the right, objects in the background, than in the right-eye view. A tree, for example, some distance in front of a house, may appear entirely to the left of a window in the right-eye picture, whilst in the left-eye picture it may partially cover the window, or even appear on the right of it. A simple experiment may serve to render this clearer. Place an object —a lamp or, better, a rod—in a vertical position, on a table, several feet from the observer, so that it appears, viewed by both eyes, to be about in the direction of an object on the wall, the right-hand edge of a picture-frame, for example. Upon closing the right eye, the rod will appear projected upon the wall to the right of the picture-frame; upon closing the left eye, and retaining the head in its previous position, it will be found to cover a portion of the picture, or will appear

to the left of its previous position. If a second rod were placed between the first and the wall, a similar result would be noticed, except that its change of position would not be as great; it would not move as far to the right when seen by the left eye, nor as far to the left when seen by the right eye.

If drawings were to be made on the plane of the wall, or upon a pane of glass interposed between the eye and the first rod, by the right and left eyes alternately, it would be found that they would substantiate the rule laid down. The previous statements might have been made in reverse order—that is, that objects in the *background* appear further to the *left* in the left-eye view, and so forth, and after performance of the experiment given it would seem to be the more natural way of stating the fact, as, on alternately opening and closing each eye, the objects in the back-ground appear to march and countermarch past the rod in front. But, in making a practical application of the rule in assorting pairs of unmounted stereographs, it seemed most convenient, generally, to select an object in the foreground, and notice its projection upon some object in the background.

The experiment has been thus fully described because it has but recently been published, in a somewhat different form, in an article upon "The Stereograph," in one of our journals of high scientific character, but it is so stated that it is made to illustrate a directly opposite, and erroneous, result, and other statements are made, apt to mislead or confuse, in regar to the character of binocular pictures.

In some cases, and perhaps most frequently, the law of difference between the binocular pictures is differently stated. Inspection of figs. 5 and 6 will show that similar points of the circles representing the nearer base are nearer together than similar points of the circles representing the more remote base; or the rule may be stated that, in *the right and left-eye views of any object, when arranged with the right-eye picture on the right side, and the left-eye picture on the left side, the distance between similar points of objects in the foreground is less than the distance between similar objects in the background.* Any stereograph will afford a verification of this statement, if the distance between similar points in the foreground is compared with the distance between similar points in the background, by means of a pair of compasses. Or drawings may be made, which will exhibit relief, when united by means of the stereoscope, if this rule is adhered to. If, for example, two diagrams were desired, which, viewed by aid of the stereoscope, should produce the effect of a frus-

tum of a cone, with its smaller base more remote, all that would be necessary would be to make the distance between the similar points, or the centres of the interior smaller circles, fig. 6, greater than that between similar points of the larger circles, instead of smaller, as in the figure. Or, if a drawing of a geometrical solid is given, and a diagram desired which shall give, in connection with it, a view in relief, it is only necessary to pay attention to the above rule in order to execute it. Regarding the diagram, at will, either as a left or right-eye view, lay or draw it on a card; then, starting with the most remote point represented, lay off with compasses a point corresponding to it, about $2\frac{3}{4}$ inches to the right or left, and then points corresponding to nearer angles at a distance a little less, say ^{1} of an inch, depending on the difference of distance from the observer to be represented; and, when points corresponding to all the angles have been laid off in this way, connect them by lines, and the stereograph will be complete. This method, theoretically, can be employed for all kinds of subjects, but practically its application is very limited. Thus, the delineation of the corresponding picture of a complicated view, as of a landscape, would not only be tedious, but impossible; much more so the delineation of a picture to supplement a drawing of a human countenance. But beautiful collections of crystal-models, optical diagrams, &c., can be produced in this way better than in any other. One point to be attended to is, that the difference of distance of points in the remote background should not exceed the difference of distance of objects in the extrême foreground by more than about two-tenths of an inch for the average interocular distance. The distribution of this difference of distance, between objects from background to foreground, depends, of course, upon their distances from the spectator, and is a subject of mathematical calculation; but, with a little practice, very good drawings of crystal-models can be made without mathematical distribution of this variation of distance. A very ingenious and practical method, and withal a comparatively rapid one, together with a simple instrument, was devised by Professor Rood for executing stereoscopic drawings by hand, and with it tables given for the distribution of the displacement from background to foreground. (Silliman's Journal, second series, Vol. xxxi, p. 71, 1861.)

If a picture of any object be taken photographically, by means of a camera, and the camera then be moved to the right or left about $2\frac{1}{2}$ inches, and another picture taken, these two pictures would evidently

be right and left-eye pictures. In practice two lenses are usually attached to one camera, at about the interocular distance from each other, and the images formed by them fall upon the ends of the same glass plate, a partition in the camera preventing their overlapping on the central part of the plate. One advantage, in addition to others, in the use of two lenses, is that, since both pictures are taken at the same time, there will be no possibility of difference between the pictures owing to presence or absence of movable objects in one or the other, as might be the case when two exposures are necessary.

Since the images are formed by the lenses in an inverted position upon the plate, laterally as well as vertically, upon holding the plate in its proper position the right-eye picture will appear on the left side, and the left-eye picture on the right side. The same will be true of the paper prints taken from it, if it be used as a negative. In order, therefore, to view them in either case by means of the stereoscope, they must be cut apart and transposed.

Much has been written, and many rules have been given, in regard to the regulation of the distance between the lenses in photographing different objects, and different distances, in order to produce the best possible effect by the pictures in the stereoscope. It seems very evident that, in order to produce a natural effect such as is received by looking at an object with both eyes, the lenses, representing the eyes, in drawing the pictures, should be separated about as far as the eyes are. When this rule is observed, however, many views do not manifest that satisfactory, almost surprising relief, that was the charm of the stereoscopic combination of pictures upon the introduction of that instrument. In a landscape, for example, without very decided foreground, and that, perhaps by reason of this fact, reduced in extent in the picture, the prominent objects will lie beyond the range of binocular effect. Consequently an effort was made, and rules empirically established, to give to all subjects more or less decided effect in the binocular pictures. The lenses were separated several feet instead of inches, the binocular parallax increased, and pictures produced which would give an exaggerated, yet in some cases more interesting effect in the stereoscope. In views of this kind, and the writer has met with some Swiss views in the market, in which this artifice had been employed, and has taken them himself with a separation of eight feet for the lenses, the houses and other objects seem to stand out much more decidedly than would be natural, and seem more like toy affairs than realities, the view being, in fact, such as a

giant, with his eyes several feet apart, would get. Whilst it may be conceded, then, that some subjects may be improved by a wider separation of the lenses than three inches, as some landscapes, but more especially clouds, &c., it must be remembered that, in case of this further separation, objects in the foreground show a disposition to resist combination in the stereoscope, and if the separation of the lenses is very great, or the objects are in the immediate foreground, they cannot be made to combine. Whilst the safest distance for uniform practice is the natural one of about three inches, the thoughtful photographer pays great attention to the selection of a pleasing and decided foreground, which, since it falls within the range of binocular effect, will impart a pleasing character to the whole picture.

The apparently full discussion of this subject of the stereograph, incited in part by the article previously referred to, is more particularly due to the remembrance of the confusion occasioned by the manner in which it is discussed, and the carelessness in the arrangement of the figures, in perusiug for the first time Sir David Brewster's treatise on the stereoscope. (London, 1856.)

He gives a diagram, "fig. 19," of the character of fig. 5, in which, however, the plane of the smaller and nearer base is assumed as the plane of projection of the right and left-eye pictures, instead of a plane in front, as in fig. 5, and subsequently he gives a figure, "fig. 20," similar to fig. 6, except that the right and left-eye pictures are reversed; that is, the centres of the small circles are more distant than those of the larger ones. He then states: "If we now separate, as in fig. 20, the two projections shown together on fig. 19, we shall see that the two summits, C, D, *c*, *d*, of the frustum are farther from one another than the more distant bases, A, B, *a*, *b*, and it is true, generally, that *in the two pictures of any solid in relief, the similar parts that are near the observer are more distant in the two pictures than the remoter parts, when the plane of perspective is beyond the object.* In the binocular picture of the human face, the distance between the two noses is greater than the distance between the two right or left eyes, and the distance between the two right or left eyes greater than the distance between the two remoter ears." Now it seems clear that drawings upon the plane of the nearer base would not only be similar to, but occupy the same relative positions as, those made upon a plane somewhat nearer the observer, and these drawings would form a diagram similar to fig. 6, when "separated," as he suggests. The plane in front was selected, in fig. 5, simply to get

rid of the confusion occasioned by overlapping pictures on the plane of the nearer base.

But the rule laid down, in italics, by Sir David, although clearly independent of his diagrams, has so much of truth in it, that it is calculated to convey a false impression in regard to binocular views. It is true, fig. 5, that in a drawing on a plane beyond the frustum, the points 1 and 2, which represent the point A of the frustum in the right and left-eye pictures respectively, are nearer together than the points 3 and 4, which represent the nearer point C; but it will also appear at a glance that the picture, as seen by the right eye, preserves the character assigned to it according to the first statement of the rule. It is a drawing precisely similar to the drawing a' b' c' d', made on the plane of projection in front. The small circle representing the nearer base is further to the left than the one that represents the more remote base. The left-eye view likewise preserves its character. In other words, if the left eye were closed, and a drawing of the frustum were made on a remote plane with the right eye, and the right eye then closed, and a drawing made with the left eye, these drawings would differ only in size from those made on the plane in front; and if the drawings were arranged with the right-eye picture before the right eye, and the left-eye picture before the left eye, the diagram would be similar to fig. 6, with the nearer points of the objects represented by nearer similar points. The rule for production of binocular views was first stated in that form because it embraced the essential conditions of difference in the right and left-eye pictures. The second statement of it depends upon the fact that the instruments usually employed in aiding the eyes in combining, so to speak, these dissimilar pictures, require the right-eye picture to be on the right side, the left-eye picture on the left side; but, had it been more convenient to construct and use an instrument,—and one could easily have been devised,—that would have required the right-eye view on the left side, and *vice versa*, in order to present to each eye its proper view, stereographs would have been generally so constructed, and the rule for their construction would have been that similar objects in the foreground should be farther apart than those of the background, and great trouble would have been spared in the preparation of photographic stereographs, because the similar pictures must be cut apart, or the negative must be cut previous to printing, in order to place them in the position now required. But, whatever arrangement the contrivance enabling us to unite them might demand, the picture for each

eye would retain its essential characteristics, as enunciated in the first general statement. It matters not in what way or by means of what instrument the right-eye picture is presented to the right eye,—thus producing the same retinal impression on that eye as the object itself, —and the left-eye picture to the left eye, or whether the optic axes have crossed each other in the production of the pictures on a remote plane, or have not so crossed, in their production upon the nearer and usual plane, the object will appear in relief in all cases in which the retinal impressions produced are such as the object itself produces. If, therefore, the pictures have been drawn on a remote plane, by crossing the directions of the optic axes, and their relative positions are preserved in the diagram, it will be necessary to cross the optic axes, or squint, in viewing them, so that each eye may see its own view; or the picture may be transposed and viewed without squinting, just as ordinary stereographs, produced on a plane in front, with the proper view before each eye, must be transposed, if viewed by crossing the optic axes in front, by squinting. It is because this last method of viewing stereographs seemed to present some advantages in the explanation of stereoscopic vision, that Sir David Brewster was led into the form of statement made, and the general confusion in discussion of this subject at the place mentioned, and subsequently in the eighth chapter of his book.

SPECTROSCOPIC NOTES.

By C. A. Young, Ph. D., Prof. of Natural Philosophy and Astronomy in Dartmouth College.

On the construction, arrangement and best proportions of the instrument with reference to its efficiency.

The spectroscope consists essentially of three parts—a prism or train of prisms to disperse the light, a collimator as it is called, whose office is to throw upon the prisms a beam of parallel rays coming from a narrow slit, and a telescope for viewing the spectrum formed by the prisms.

Supposing the slit to be illuminated by strictly homogeneous light, the rays proceeding from it are first rendered parallel by the object-glass of the collimator, are then deflected by the prisms and, finally, received upon the object-glass of the view-telescope, which, if the focal lengths of the collimator and telescope object-glasses are the same, forms at the focus a real image of the slit, its precise counter-

part in every respect except that it is somewhat weakened by loss of light and slightly curved.*

If the focal length of the view-telescope is greater or less than that of the collimator, the size of the image is proportionally increased or diminished.

This image is viewed and magnified by the eye piece of the telescope.

If now the light with which the slit is illuminated be composite, each kind of rays of different refrangibility will be differently reflected by the prisms, and form in the focus of the telescope its own image of the slit. The series of these images ranged side by side in the order of their color constitutes the spectrum, which can be perfectly pure only when the slit is infinitely narrow (so that the successive images may not overlap), and accurately in the focus of the object-glass of the collimator, which object-glass, as well as that of the telescope, must be without aberration either chromatic or spherical, and the prisms must be perfectly homogeneous and their surfaces truly plane.

Of course, none of the conditions can be strictly fulfilled. An infinitely narrow slit would give only an infinitely faint spectrum; and no prisms or object-glasses are absolutely free from faults. A reasonably close approximation to the necessary conditions can, however, be obtained by careful workmanship and adjustment, and it becomes an important subject of inquiry how to adapt the different parts of the instrument to each other so as to secure the best effect, and how to test separately their excellence, in order to trace and remedy as far as possible all faults of performance.

With reference to the battery of prisms, several questions at once suggest themselves relative to the best angle and material, the number to be used, the methods of testing their surfaces and homogeneity, and the most effective manner of arranging them.

Angle and material of the prisms.—As to the refracting angle the careful investigation of Professor Pickering, published in the American

* The curvature arises from the fact that the rays from the extremities of the slit, though nearly parallel to each other, make an appreciable angle with those which come from the centre. They therefore strike the surface of the prisms under different conditions from the central rays and are differently refracted, usually more. The higher the dispersive power of the instrument and the shorter the focal length of the collimator, the greater this distortion, which is also accompanied by a slight indistinctness at the edges of the spectrum.

Journal of Science and Art for May, 1868, puts it beyond question, that with the glass ordinarily employed an angle of about 60° is the best. For instruments of many prisms there is an advantage as regards the amount of light in making the angle such that the transmitted ray at each surface shall be *exactly* perpendicular to the reflected. For ordinary glass, the refracting angle determined by this condition somewhat exceeds 60°; for the so-called "extra-dense" flint it is a little less.

The high dispersive power of this "extra-dense" glass is certainly a great recommendation. But it is very yellow, powerfully absorbing the rays belonging to the upper portion of the spectrum, and is very seldom homogeneous. It is so soft also, and so liable to scratch and tarnish, that it can only be safely used by casing it with some harder and more permanent glass, as in the compound prisms of Mr. Grubb, and the direct vision prisms of many makers.

For many purposes these direct vision prisms are very convenient and useful, but they are hardly admissible in instruments of high dispersive power designed to secure accurate definition of the whole spectrum, the violet as well as the yellow.

Test for flatness of surface.—For testing the *flatness* of the prism surfaces, probably the best method is to focus a small telescope carefully upon some distant object (by preference the moon or some bright star), and then to scrutinize the image of the same object formed by reflection from the surface to be tested. Any general convexity or concavity will be indicated by a corresponding change of focus required in the telescope; any irregularity of form will produce indistinctness, and by using a card-board screen perforated with a small orifice of perhaps $\frac{1}{4}$ inch in diameter, the surface can be examined little by little, and the faulty spot precisely determined.

Test for homogeneity.—It is not quite so easy to test the homogeneity of the glass. Any strong veins may, of course, be seen by holding the prism in the light, and if the ends of the prism are polished, the test by polarized light will be found very effective in bringing out any irregularities of density and elasticity in the glass. A blackened plate of window glass serves as the polarizer; a Nicol's prism is held in one hand before the eye in such a position as to cut off the reflected ray, and with the other hand the glass to be tried is held between the Nicol and the polarizer. If perfectly good it pro-

duces no effect whatever; if not it will show more or less light, usually in streaks and patches.

On the whole, however, the method of testing which has been found most delicate and satisfactory is the following:

A Geissler tube containing rarefied hydrogen is set up vertically, and illuminated by a small induction coil.

A small and very perfect telescope of about six inches focus is directed upon it from a distance of seventy-five or one hundred feet, and carefully adjusted for distinct vision.

The prism to be tested is then placed in front of the object-glass of the telescope with its refracting edge vertical, adjusted approximately to the position of minimum deviation, and telescope and prism together then turned (by moving the table on which they stand), until the spectrum of the tube appears in the field of view. This spectrum consists mainly, as is well known, of three well-defined images of the tube, of which the *red* image, corresponding to the C line, is the brightest and best defined, and stands out upon a nearly black background.

Supposing then the *flatness* of the prism surfaces to have been previously tested and approved, the goodness of the glass may be judged of by the appearance and behavior of this red image, and by using a perforated screen in the manner before described, inequalities of optical density are easily detected and located. Irregularities, which would hardly be worth noticing in a telescope object-glass, where the total deviation produced by the refraction of the rays is so small, are fatal to definition in a spectroscope, especially one of many prisms, and it is very difficult to find glass which will bear the above-named test without flinching.

Of course it must be conducted at night, or in a darkened room.

Number and arrangement of prisms.—The number of prisms to be employed will depend upon circumstances. If the spectrum to be examined be faint, and either continuous or marked with dark lines, or by diffuse bands either bright or dark, we are limited to a train of few prisms.

The light of the sun is so brilliant that, in studying its spectrum, we may use as many as we please. The light is abundant after passing through 13, and I presume would still be so if the train were doubled.

Spectra of fine well defined *bright lines* also bear a surprising num-

ber of prisms. The loss of light arising from the transmission through many surfaces is nearly, if not quite, counterbalanced by the increased blackness of the background, and the greater width of slit which can be used.

As to the best arrangement for the prisms this also must be determined by circumstances.

Where exact measurements are aimed at, as, for instance, for the purpose of ascertaining the wave-length of lines, or the dispersion coefficient of a transparent medium, the prism or prisms ought to be firmly secured in a positive and determinable relation to the collimator. A train of many prisms can hardly be safely used in such work on account of the difficulty in obtaining this necessary fixity, and if high dispersion is indispensable, it can only be obtained by enlarging the apparatus.

But for most purposes it is better that the prisms, instead of being fixed, should be mounted upon some plan which will secure their automatic adjustment to the position of minimum deviation.

Having now thoroughly tried the plan which I proposed and published in this Journal last November, I am prepared to say that I cannot imagine anything more effective and convenient.

The arrangement of Mr. Browning and its extension by Mr. Proctor, are equally effective so far as the adjustment of the prisms is concerned, but are less compact and simple, and do not afford the same facility in changing the number of prisms in use.

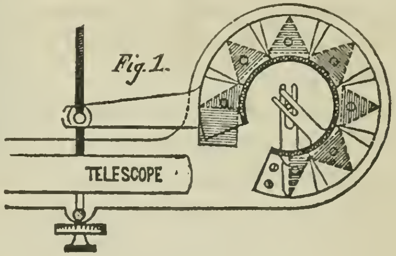
In my instrument the light, after leaving the collimator, falls perpendicularly upon the face of a half-prism, passes through the train of prisms near their bases; at the end of the train is twice totally reflected by a rectangular prism attached to the last of the train (which is also a half prism), is thus transferred to the upper story of the train, so to speak, and returns to the view-telescope, which is firmly attached to the same mounting as the collimator and directly above it. Both are immovable, and the different portions of the spectrum are brought into view by means of the screw, which acts upon the last prism and through it upon the whole train. The adjustment for focus is by a milled head, which carries the object-glasses of both collimator and telescope in or out together. Since they have the same focal length, this secures the accurate parallelism of the rays as they traverse the prisms.

The annexed diagram, taken from the paper already alluded to*,

* After the appearance of the article referred to, I found that Mr. Lockyer

exhibits the plan of the arrangement and requires no explanation, unless to add that, to avoid complication in the figure, I have represented only two of the radial forks which maintain the prisms in adjustment; also, that the prisms are connected to each other at top and bottom not by hinges, but by flat springs, preventing all shake.

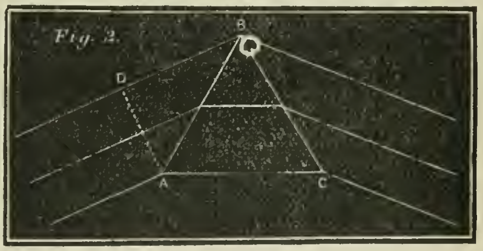
Fig. 1.



By adding another tier of prisms and sending the light back and forth through a third and fourth story, the dispersion can be easily doubled with very small additional expense, except for the prisms themselves; the mechanical arrangements remaining precisely the same.

I desire, in this connection, to call attention to the great advantages gained by the use of the half prism at the commencement of the train, a point which hitherto seems to have escaped notice.

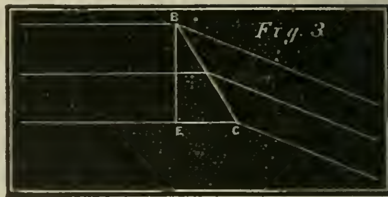
With a prism of 60°, having a mean refractive index, μ, 1·6, and placed in its best position, the course of the rays is as shown in figure 2. The side, $a\ b$, is just $1\frac{2}{3}$ times the cross section, $a\ d$, of the transmitted beam. In



had anticipated me by some months, not only in respect to the method of making the rays traverse the prism train twice, but also in the use of a half prism at the beginning of the train, and the employment of an elastic spring in the adjustment for minimum deviation. In all essential particulars his instrument is the same as mine, though in some matters of detail there are differences which have proved to be of practical importance in favor of my own.

Mr Lockyer has, however, never printed an account of his instrument, and at the time of my publication I knew only the fact (which I then mentioned), that he intended to send the light twice through the prism train by a total reflection.

The beautiful instrument recently constructed for Dr. Huggins by Mr. Grubb, differs mainly in using compound prisms, and in producing the adjustment for minimum deviation by an arrangement of link work, which, though not theoretically exact, is practically accurate.



other words a prism of the material and angle described, in order to transmit a beam one inch in diameter, must be one inch high and have sides $1\frac{2}{3}$ inches long.

But when the light is received perpendicularly upon the face of a half prism, as in figure 3, then, since $b\,c = b\,e \div \cos 30°$, the length of the prism side, $b\,c$, requires to be only 1·155 times as great as the diameter of the transmitted beam.

Thus a train of prisms each 1 inch high, and having the sides of their triangular bases each 1·155 inches long, led by an initial half prism in the way indicated, would transmit a beam 1 inch in diameter, while without the initial half prism the sides would have to be 1·667 long, the surface to be worked and polished would be 1·44 (*i. e.* 1·667 ÷1·155) times as great, and the quantity of glass required 2·08 (*i. e.* $1{\cdot}44^2$) times as great. With a higher index of refraction the gain is still greater.

This advantage of course is not obtained without losing the dispersive power of one half prism. But where the train is extensive this loss is comparatively insignificant, and may be made up by a slight increase of the refracting angles. Indeed, in an instrument of the form above described, it is necessary, if the train is led by a *whole* prism, to reduce the refracting angle from 60° to about 55°, in order that the reflecting prism at the end of the train may not interfere with the collimator, while with the initial half prism, the full angle of 60° can be used, so that in this case there is practically no loss whatever.

It would seem to deserve consideration, whether in the construction of spectroscopes to be used with some of the huge telcscopes now building, it may not be advisable to carry the principle still farther, by employing *two* or more half prisms at the beginning of the train in order to economize material and weight.

Dispersive efficiency.—The dispersive efficiency of a spectroscope is its ability to separate and distinguish spectral lines whose indices of refraction differ but slightly; it is closely analogous to the *dividing-power* of a telescope in dealing with double stars. It depends* not

* It is very common to describe the dispersive power of a spectroscope as being equivalent to a certain number of prisms, or a certain number of degrees from A to H. But either method fails entirely to convey an idea of the ap-

only upon the train of prisms, but also upon the focal lengths of the telescope and collimator, the width of the slit and the magnifying power of the eye-piece.

As has been said before, each bright line is an image of the slit whose *magnitude*, referred to the limit of distinct vision, depends upon the telescope and collimator, but is independent of the prism train. The *distance* between the centres of two neighboring lines, on the other hand, depends upon the number and character of the prisms, the focal length of the telescope and the magnifying power of its eye-piece, but is totally independent of the collimator.

In order that two lines may be divided, it is necessary that the *edges* of their spectral images should be separated by a certain small distance—a *minimum visible*, whose precise value is of no particular importance to our present purpose, but which I suppose to be about $\frac{1}{500}$ of an inch.

From these principles it is easy to deduce a formula which will express the dispersive efficiency of a given instrument, and enable us to judge of the effect of variations in the proportion and arrangement of the parts.

Let f be the focal length of the collimator.

f^1 " " " telescope.

m the magnifying power of the eye piece, (which is found by dividing the limit of distinct vision by the equivalent focal length of the eye-piece and adding unity to the quotient.)

n the number of prisms in the train.

w the width of the slit.

k the *mimimum visibile* above alluded to.

d μ, the difference between the indices of refraction for two adjacent lines, and finally

δ, the co-efficient of dispersion for each prism, (which, r being the refracting angle of the prism, is given by the equation

$$\delta = \frac{\sin \frac{1}{2}\, r}{\sqrt{1-\mu^2 \sin^2 \frac{1}{2}\, r}})$$

If, now, we put D for the distance between the centres of the two lines, and b for their breadth, we shall have

pearance of the spectrum in the instrument, and it is much better to name the closest double line which it will divide, or else to give the distance between the two D lines, either linear, (referred of course to the limit of distinct vision), or angular. If we know, for example, that the D lines are separated 1°, or, what comes to the same thing, appear to be one-sixth of an inch apart, we have a definite idea of the power of the instrument.

$$D = m\, n\, s\, \delta f^1 .\ d\, \mu, \text{ and}$$
$$b = m\, w\, f^1 \div f.$$

But the distance between the edges of the lines equals $D—b$; and this, for two lines as close as the instrument will divide, must equal k. Hence $k = m\, n\, \delta\, f^1 .\ d\, \mu - \frac{m\, w\, f^1}{f}$. Finding from this the value of d μ, taking its reciprocal as a measure of the dispersive efficiency of the instrument, and calling it E, we get

$$E = m\, n\, \delta \quad \frac{f f^1}{kf + mwf^1}. \quad (1)$$

This formula, in which m, n and δ appear as simple factors, of course supposes that the perfection of workmanship and intensity of the light are such that there is no limit to the magnifying power and number of prisms which may be employed.

My special object, however, in working it out has been to exhibit clearly what is evident from its last term, the dependence of the dispersive efficiency upon the focal lengths of collimator and telescope.

Differentiating equation (1) with respect to f and f^1 we obtain

$$d\, E = m.\ n.\ \delta \quad \left\{ \frac{kf^2(df^1) + mwf^1(df)}{(kf + mw\, f^1)^2} \right\} \quad (2)$$

which shows that any increase in either f or f^1 adds to the dispersion. If f increases, both D and b increase in the same proportion, and so, of course, does the width of the interval between the adjacent lines; while every augmentation of f^1 decreases the width of the spectral images without in the least affecting the distance between their centres.

This principle seems to have been often overlooked, and collimators and telescopes of short focus employed when longer ones would have been far better.

In spectroscopes designed to be used for astronomical purposes at the principal focus of a telescope, there is, of course, no advantage in making the angle of aperture of the collimator much greater than that of the equatoral itself; accordingly a collimator of one inch aperture ought to have a focal length of 10 or 12 inches, or, if special reasons determine a focal length of only 6 inches, then it is needless to make the collimator and view telescope much over half an inch in diameter, and the prisms may be correspondingly small.

If, on the other hand, the focus of telescope or collimator is lengthened for the purpose of securing increased dispersion, object glasses

and prisms must also be correspondingly enlarged, in order to transmit the same amount of light.

It is, perhaps, worth noting that when f and f^1 are equal formula (1) becomes simply

$$E = \frac{m.\ n.\ \delta.\ f}{k + mw}. \quad (3)$$

Luminous Efficiency.——The extreme faintness of many spectra greatly embarasses their study, so that it becomes a matter of interest to examine how the different dimensions and proportions of a given instrument stand related to the brightness of the spectrum produced.

It appears to be necessary, for this purpose, to distinguish two classes of spectra, those composed of narrow and well defined *bright lines*, and those which are not, the light being spread out more or less evenly and continuously.

The brightness of a spectrum of the latter kind is evidently directly proportional to the amount of light admitted, diminished by its subsequent losses, and inversely to the area over which it is distributed; similar considerations apply in the first case, only as the lines are exceedingly narrow images of the slit, their brightness, being independent of their distance from each other, is inversely proportional to the length of the lines simply—*i. e.* to the *width* of the spectrum, having nothing to do with its *length*.

Using the same notation as before, merely adding

$i =$ intensity of source of light.

$l =$ length of the slit.

$a =$ linear aperture of the collimator object glass; and supposing the prisms and view telescope of a size to take in the whole beam transmitted by the collimator, and that the angular magnitude of the luminous object, as seen from the slit, is sufficient to furnish a pencil large enough to fill the collimator object glass, we shall then have for the quantity of light transmitted to the prisms the expression

$$i\,l\,w\frac{a^2}{f^2}.$$

This is afterwards diminished in passing through the prism train and telescope.

To estimate the precise amount of this loss is very difficult, and the algebraic expression for it is of so complicated a character that it would be of little use to attempt to introduce it into our formula. Calling it S, however, (which of course is a function of the number and refracting angle of the prisms, as well as of the optical character of

the glass) we may write for the quantity of light effective in forming the spectrum.

$Q = i\,l\,w\frac{a^2}{f^2} - S.$ And this expression applies to both kinds of spectra—bright line and continuous.

In the continuous spectrum this light is spread out over an area whose length is the angular dispersion of the train *$\triangle$, multiplied by the magnifying power of the eye-piece and by the focal length of the view telescope, and whose breadth is the width of the spectrum. Putting A for this area we have

$$A = \frac{l\,m^2 n.\triangle.f_1{}^2}{f}.$$

And for the intensity of light in the continuous spectrum, which equals $Q \div A$, we get finally

$$L = \frac{i\,l\,w\,a^2 - f^2\,S}{l\,m^2\,n\,\triangle\,f_1{}^2 f}. \quad (4)$$

If we neglect the loss of light in transmission and take $f = f^1$, the formula simplifies itself to

$$L^1 = \frac{i\,w\,a^2}{m^2\,n\,\triangle\,f^3}. \quad (5)$$

Either of these formulæ shows how rapidly the light is cut down by any increase of the dispersive power, whether by adding to the prism train or by enlargement of the linear dimensions of the apparatus.

Our only resource in dealing with spectra of this kind, when the limit of visibility on account of faintness is nearly attained, seems to be either to increase i or a. If the luminous object be a point (like a star) we can do the former by concentrating its light on the slit with a lens; if it be diffuse, like the light of the sky, I know no means for producing the desired concentration, and we can only gain our end by increasing the angular aperture of the collimator.

For the discontinuous bright-line spectrum the case is quite different. Q, *i. e.*, the quantity of light which goes to form the spectrum, remains unchanged, but instead of A the whole area covered by the

*$\triangle = n\ (\mathrm{Sin}^{-1}\ (\mu_H \times \mathrm{Sin}\ \frac{1}{2}\ r) - \mathrm{Sin}^{-1}\ (\mu_A\ \mathrm{Sin}\ \frac{1}{2}\ r))$ where μ_A and μ_H are respectively the indices of refraction for the lines A and H; the prisms being supposed to be so mounted as to maintain the position of minimum deviation.

spectrum we have only to consider its width, *i. e.*, the *length of the lines.

We then have $A^1 = \frac{l\,m\,f^1}{f}$;

and for the brilliance of the bright line spectrum we get

$$A = \frac{Q}{A'} = \frac{i\,l\,w\,a^2 - f^2\,S}{l\,m\,f\,f^1}. \quad (6)$$

If we neglect S, the loss of light in transmission through the apparatus, and suppose $f = f^1$ this becomes

$$A' = \frac{i\,w\,a^2}{m f^2} \quad (7)$$

These formulæ show that with a spectrum of this kind we may, without diminishing the brightness of the lines, increase the dispersive power of our instrument to any extent by increasing its linear dimensions; if we increase the dispersive power by adding to the prism train the case is different, since S is a function of n, the number of prisms.

New form of Spectroscope.—I close the article with the suggestion of a new form for a chemical spectroscope, which seems to present some advantages in the saving of material and labor as well as of light.

The figure sufficiently illustrates it, except that it may be necessary to add that I have not represented any of the many possible convenient arrangements for reading off the positions of lines observed. The centre of motion for the telescope is at c, the collimator remaining fixed.

The half prisms of heavy flint glass are concave at the rear surface and directly cemented to the single crown glass lenses, which form the object glasses of telescope and collimator. There is thus a saving of two surfaces over the common form; and what is more important,

* So long as the opening of the slit is small enough to secure accurate definition of the lines it is not necessary to take into account either this or the magnifying power as diminishing the brightness of the lines by increasing their breadth, since irradiation alone gives them a sensible width sufficient to render the effect of other causes comparatively unimportant.

the prisms to fit telescopes of a given aperture are considerably smaller on the face, and can be made from plates of glass of less than half the thickness required by the ordinary construction, a circumstance which greatly reduces the difficulty of obtaining suitable material.

Franklin Institute.

Proceedings of the Stated Meeting, June 21st, 1871.

The meeting was called to order by the President, Mr. Coleman Sellers.

The minutes of the last meeting were read and approved.

The Actuary, *pro tempore,* submitted the minutes of the Board of Managers and reported that, at their meeting held June 14th, donations to the library were received from

The U. States Patent Office, Washington, D. C. C. E. Rice, C. E. Frederick Graeff, Annual Report of the Chief Eng. of the Water Department of the City of Philadelphia. Board of Public Charities, New York, their Report for 1870. Navy Department, the Naval Register of the United States for 1871. John C. Cresson, the Third Annual Report of the Commissioners of Fairmount Park, Philada.

The Institute of Actuaries, the Societies of Arts, the Chemical Royal Astronomical and Royal Geographical Societies, of London. The Manchester Steam Users Association, of Manchester, England. The Austrian Society of Engineers and Architects, Vienna. And from D. S. Holman and William H. Wahl.

The Actuary, *pro tem.*, likewise reported the following resolutions from the Board:

Resolved, That in view of the long and faithful services of William Hamilton, late Actuary of the Franklin Institute, the Board recommend to the Institute at its next meeting to take measures for the erection of a memorial stone or monument over his grave.

Resolved, That, in the event of the adoption by the Institute of this recommendation, a committee of five be appointed to define the character of the memorial, ascertain its cost and to prepare subscription lists to defray the same.

The resolutions herewith presented were unanimously adopted by the Institute, and the President was requested to appoint the committee.

The Committee consists of Messrs. J. V. Merrick, Frederick Fraley, Wm. Sellers, B. H. Moore, W. Jones.

The Secretary next read his Monthly Report on Science and the Arts, after which the meeeting adjourned.

WILLIAM H. WAHL, *Secretary.*

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXII.] DECEMBER, 1871. No. 6

EDITORIAL.

ITEMS AND NOVELTIES.

Mineral Cotton.—At the last meeting of the Franklin Institute Mr. Coleman Sellers exhibited a sample of a material which we believe is now for the first time about to be manufactured and applied to useful purposes in the arts.

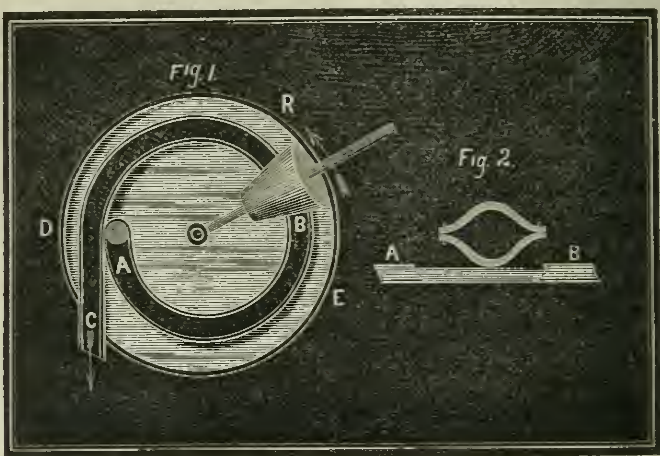
The product possesses a general resemblance to cotton wool, for which it may doubtless in certain cases be substituted with advantage, but on closer examination seems more like a spun glass, which in reality it is. It is formed by allowing a jet of steam to escape through a stream of liquid slag, by which it is blown into the finest threads, sometimes two or three feet in length. These threads, though somewhat elastic, readily break up into much smaller ones, and, the color of the substance being white, the appearance of a compacted mass of it makes the name under which it has been described a very appropriate one. The admirable non-conducting property of the material for heat, as well as that of the great quantity of air which it retains in its interstices, would seem to fit it very well for a non-conducting casing to steam-boilers and pipes, an application for which it is at present being tested.

The Business of the Suez Canal.—From the tabulation of the Austrian Consul at Port Saïd it appears that the number of vessels which passed through the canal in the direction of Suez during the year just passed amounted to 292, while in the opposite direction 199 made the passage. Representing the nationality, the 491 vessels would be divided as follows:

English,	314	Spanish,	3
French,	74	Dutch,	3
Egyptian,	33	American,	2
Austrian,	26	Russian,	2
Turkish,	18	Danish,	1
Italian,	10	Greek,	1
Portugese,	3	Zanzibar,	1

The total receipts of the canal company amounted to 5,070,093 fcs.

A Peristaltic Machine.—That is, a simple water-pump, "in



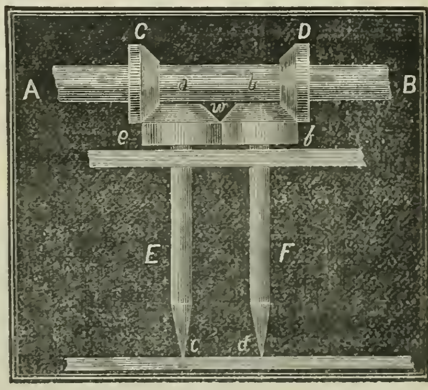
which A B C, fig. 1, is a spiral tube, duly fastened to the bottom of a shallow tub, D E. At B is seen a conical roller, having the middle of the bottom of the tub for its summit and center of motion. The tube A B C occupies rather more than one circumference, so that the cone presses, during a small part of its revolution. on both spires at once, by which means the machine *would act* without even one valve, though it is better to place one *under* the opening, A. Now observe the operation as the cone rolls over the tube, round the common center, in the direction of the arrow, R. The water enters behind it,

through the opening, A (for the tube is plunged a few inches into the water), and is forced by its pressure into the ascending tube, which is a continuation of A B C.

"It would be superfluous to add that these tubes are shown in the figure *as cut open*, and presenting their inside to view."

"An objection may occur to some, at sight of this machine, namely, that the roller or cone, B, would soon destroy the flexible tubes, by their excessive pressure. But, to obviate this diffficulty, I have added, in fig. 2, a form of tube (supposed of leather) which insures a proper *position* of the tube under the roller, accompanied by ledges A B, on which their surplus weight would lean, so as to annul every excess of pressure on the tube."—*Century of Inventions.* James White. 1822. J. H. C.

Anti-friction Device.—"A B is an axis which it is desirable to divest of its *friction*. To do this, as nearly as may be, I connect with it two rings of hard metal, C D, formed as truncated cones, and under the shaft, in the same vertical plane, I place two smaller shafts, E F, carrying on their tops other two cones, similar to the former.



"The summits of each pair of cones meet, of course, in the points a b of the main shaft; and, on the principle of bevel-gear, every contiguous part of the touching cones moves with the same velocity, so that there is no sensible *rubbing* between them; for, 1st, the pivots c d are hard and pointed, and run on the hardest *steps* that can be obtained; and, 2dly, the tendency of the cones, u, towards each other is repelled without friction by the cylinders, e f, attached to them, and which *lean* right and left against each other, turning with the same velocity, without causing any friction or any *creeping* between the two pairs of cones e C and f D. All the weight, therefore, of the shaft A B (which, of course, is kept in place in the other direction by proper side checks, &c.), rests on the points of the vertical shafts E F, accompanied by no sensible tendency of these points to quit the places assigned to them."—*Century of Inventions.* James White. 1822. J. H. C.

The Comparative Efficiency of Boiler Plates.*—Messrs. Whelpley & Storer communicate to a contemporary the results of tests made with nine different brands of boiler plates, with reference to the determination of their heat transmitting and steam generating efficiency. The estimation of the results was made from the relative generation of steam under similar conditions. The thickness of the plates was uniform ($\frac{5}{16}$ of an inch); the temperature of the flame varied but a trifle from 550° Fahr., and the time of evaporation of water but a few seconds.

Allowing the plate of lowest transmitting power to have the value 100, the relative efficiency of the others will be indicated in the following tabulation:

1	Power of Transmission,	100
2	" "	104·4
3	" "	117·7
4	" "	118·8
5	" "	121
6	" "	123
7	" "	123·3
8	" "	141·9
9	" "	144

To generate an equal amount of steam, in equal times and under similar conditions of fuel and draft, boilers made of Nos. 8 and 9 plates would consume constantly 40 per ct. less than boilers made of plates Nos. 1 and 2.

The authors very sensibly conclude by directing attention to the vastly greater efficiency of the best qualities of plate in the generation of steam. The possibility of a saving of 40 per ct of fuel is certainly an inducement to purchase the best plates.

Testing of Boilers.—A really useful and positively determinative test of competing boilers has taken place at the Fair of the American Institute, under the direction of the Committee on Engines and Boilers, Prof. R. H. Thurston (*Stevens' Institute of Technology*), chairman, T. J. Sloan and R. Weir, members.

Instead of weighing the water fed into the boiler and the fuel consumed, and reporting their ratio as the evaporative efficiency of the boiler, a method has been adopted that enables the committee to report the real evaporation and also the amount of water carried over, unevaporated, by the steam.

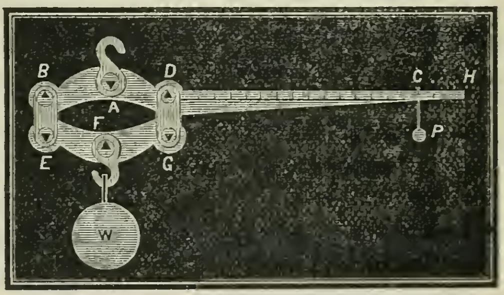
* Sci. Amer. xxv, 324.

A large surface condenser has been prepared, of about 1100 square feet of condensing surface. The steam from the boiler is blown off at a pressure of 75 pounds into this condenser, and the *quantity of heat* carried over by it is measured in thermal units. Should this amount be greater than would be transferred by saturated steam, it shows the steam to have been superheated; and if the amount is less than would have been necessary to fully evaporate all water passing out of the boiler, it indicates that the steam was wet, and a simple calculation gives in each case the exact weights of steam and of water passing into the condenser.

The quantity of feed and of injection water is measured by meters, the water of condensation by weighing, and the temperatures of steam, feed, injection water, water of condensation, and of discharge water from condenser, are carefully taken, and the temperature of the gases in the flues is taken by a pyrometer.

The results are reported to be very satisfactory, both as a test of this method and of the boilers competing. We shall obtain the results as soon as they are made public. They will be exceedingly interesting to engineers and to the public.

A Differential Steelyard.—"Suppose the arm, A C, to be 4 feet in length, and the difference between A B and A D $\frac{1}{10}$th of an inch, and E G equal to B D, and E F and F G equal, then the power of the weight, P, to raise the load, W, is as 48 inches to $\frac{1}{10}$th of an inch, or as 480 to 1; so that if the weight P were 10 lbs. this steelyard would weigh 4800 lbs.; and it is easy to see that this power can be almost indefinitely extended."—*Century of Inventions.* James White. 1822.



J. H. C.

A New Street Lamp.*—Mr. Skelton has invented a plan of utilizing much more of the light than is usually economized in lamps and lanterns. It is evident that the rays of light which enter the eye of a spectator on the ground form only a fraction of those given

* Jour. App. Chem., vi, 172, from Nature.

out by the flame. Those passing through the upper portion of the sides and roof are either entirely lost or, at least, but very imperfectly reflected by clouds, &c., and become visible only in the glow which hangs over a distant city. The principle of the inventor is to apply a number of reflectors, in such positions as to bend downwards and utilize the light now wasted by upward radiation. The upper half of each side of the lamp, and all of the sloping sides of the roof, are occupied by a frame in which strips of looking-glass are arranged with their reflecting surfaces downwards, in a manner analogous to the laths of a Venetian blind. The plan is applicable to any form of lamp, and cannot fail to prove serviceable.

Phosphorus Bronze.—Some recent experiments, made for a committee of the French Academy, upon the properties and the merits of the application of the new alloys containing phosphorus, seem to have resulted very favorably. One of these experiments included a bursting trial of a six-pounder cannon of phosphorus bronze, compared with a similar gun in ordinary bronze cast at the royal foundry at Liège; the result showing that under the bursting charges the regulation piece had burst, while the new gun could still be fired with perfect safety. The bronze employed was made by adding phosphorus copper to metal coming from old guns.

From the great hardness, toughness and stability of the new compounds, as evinced by these as well as other enumerated trials, it is safe to conclude that their future applications will be very numerous. As an example of the application of the bronze in machinery, it is stated that a pair of pinions of universal rollers had been used for ten months, and were finally destroyed by the wearing away of the teeth, none of them having been broken or split. It has also been successfully applied, according to our account, for the collars of hydraulic presses, eccentric rings for locomotives, pistons and bolts for steam cylinders, etc.

Dualin.—A series of experiments have recently been made, in Lancaster County, Pa., with the, as yet, comparatively little known explosive called Dualin. The material is described as being in the form of a powder, resembling fine saw-dust coated with oil. It is declared to possess an explosive capacity far exceeding that of nitro-glycerin, and to be withal as safe to transport or to manipulate as gunpowder. The only method of discharging it explosively is said to be by concussion. Passing over the details of the drill blasting,

which were quite satisfactory, we append the most remarkable feature of the trial—the account of the surface blasting:

"On a detached rock weighing about six tons was placed a carriage containing two pounds of the compound. This was covered with halı a bucketful of sand, and trampled down with the feet. The end of a fuse was inserted in a copper cap, a little larger than an ordinary gun cap, and the fuse ignited. . . . The rock was broken into fragments, and so disintegrated that particles taken between the fingers crumbled like dried clay."

The non-explosive character of the compound, save with the aid of a fulminator, was demonstrated by elevating with a derrick, to the height of sixty feet, a keg of the material, and allowing it to fall upon a face of rock, which experiment was not followed by a discharge.

An Electric Pyrometer.—The plan is suggested by a German *savant*, of applying the differences of resistance to the galvanic current, evinced by metals upon being subjected to changes of temperature, to the measurement of temperatures when other forms of pyrometers become unreliable.

The resistance of a wire of any metal, at a given temperature, is a measurable factor; and, in the plan above mentioned, a wire of platinum whose resistance has been determined, is placed between two cylinders of clay, and connected with a battery and with a measurer of resistance. The arrangement then is subjected to the heat to be measured.

A New Respirator.—In a recent lecture at the Royal Institution of Great Britain, Prof. Tyndall describes a new respirator, designed for the use of firemen and others for protection against smoke and the noxious vapors evolved during combustion. In the words of the lecturer, the object of the contrivance is to place it in our power to penetrate through the densest smoke into the recesses of a house, and to rescue those who would otherwise be suffocated or burnt. As constructed, after a number of experiments, it consists of a number of strata separated from each other by wire gauze. On the partition of wire gauze at the bottom of the space which fronts the mouth, is placed a layer of cotton-wool, moistened with glycerin; then a third layer of dry wool; then a layer of charcoal fragments; a second thin layer of dry cotton-wool, succeeded by a layer of fragments of caustic lime. The order of succession of the layers is unessential, and may be changed without interfering with the action of the instrument. A wire gauze

cover keeps the substances in place. The moistened cotton is designed effectually to arrest, by its adhesive action, the carbon particles constituting the smoke; and the charcoal, by its surface action, to condense the more dangerous and irritating vapors, mainly hydro-carbons, produced by imperfect combustion. The lime is for the absorption of carbonic acid; but, in an atmosphere filled with smoke, this substance is never present in dangerous quantity, and this last layer may therefore, except in special cases (in wells, mines, &c.), be safely dispensed with.

This instrument, furnished with a suitable hood, has been thoroughly tested by the Engineer of the London Fire Department, and found completely to answer the purpose of its designer.

A New Photometric Unit.*—Prof. John C. Draper proposes a new unit for photometric purposes, which, besides being theoretically much more scientific than that at present commonly used, offers no difficulties for its adoption in practice. The method of Bunsen is that usually employed, and depends upon the determination of the relative intensities of two lights, one of which is supposed to be invariable. The invariable unit in this method is the light produced by the burning of a candle; which is defined as a sperm candle of six to the pound burning at the rate of 120 grains per minute.

It will be evident, upon a little reflection, that this plan is liable to serious errors in practice, from the fact that candles can never be obtained possessing the same composition, from which it follows that the light emitted in a given time by two candles with the same consumption by weight, will be a variable, and not as the theory demands, a constant factor.

The plan suggested by Prof. Draper avoids this error completely; and consists in the adoption of the light emitted by an incandescent solid—a platinum coil—heated to a certain temperature. With a given substance, a light of a definite and measurable intensity is emitted at different temperatures. The invariability of the light from this source, at any convenient degree of heat, affords a satisfactory unit; it is only necessary that the flame employed to heat the coil shall be itself non-luminous.

The course adopted by the author is to allow a flame of pure dry hydrogen, burning at a definite rate, to impinge upon a platinum coil; and it was found on experiment, that so long as wire of the same

* Sci. Amer., October, 1871.

diameter was used in constructing coils of the same dimensions, and those were subjected to a flame of hydrogen burning at the same rate, the light emitted by the glowing wire was of the same intensity.

There can be no doubt that measurements made upon this method will be far more reliable than those made in the usual way.

The Spectrum of the Aurora. — Prof. Geo. F. Barker. Through the kindness of the author, we are in receipt of advanced sheets of the *Am. Journal of Science*, containing the results of his observation of the beautiful crimson aurora of November 9th, a fine display of which was visible at this place. The observation resulted in one point of great interest, namely, the detection of a line in the auroral spectrum not hitherto observed.

The following tabulation of the observation, with the accompanying explanation, will suffice to present the essential portion of the paper :

Line	Scale Number	Wave Length	Auroral Lines	Other measurements.
B	76	687		
C	82	656		
(1)	90	623	623	627 Zöllner
D	100	589		
(2)	110·5	562	562	557 Angström
E	124·5	527		
(3)	130	517	517	520 Winlock
b	130	517		
(4)	138	502	502	
F	146·5	486		
(5)	145	482	482	485 Alvan Clark, Jr.
G	189	431		

In this table, column 1 gives the auroral and the Fraunhofer lines ; column 2, the number of these as measured upon the scale of the spectroscope used ; column 3, the wave lengths of these lines ; column 4, the wave lengths of the auroral lines ; and column 5, the wave lengths of auroral lines noticed and measured by other observers, and which the author assumes to be identical with those opposite to them in his own observation. It will be seen that the line (4), of wave length 502 is a new one, since it appears not to have been noticed by former observers.*

* In a note appended to the above, Professor Barker mentions that the last number of the *Astronomische Nachrichten* (No. 1864), received since his notice was in type, contains an account by Vogel of the spectra of auroras seen at

The Utah Tin Discovery.—For some time past the newspapers of the country, have extensively circulated the report of the discovery of vast deposits of tin in Utah, which were declared to exceed in extent anything of the kind at present known. Samples of the ore, which had been sent to Washington for assay, are said to have been returned with the announcement that they contained on an average 37 per cent. of metal. Those who have been interested in originating and, perhaps still more so, in circulating this story of the "tin mountain," and especially those who are fortunate enough to possess stock in the company now formed to work it, will probably feel some surprise that so eminent a chemist as Dr. F. A. Genth has had the misfortune to find "not a trace of tin" in the samples submitted to him for analysis. The appended extract of a letter from Dr. G. to the Editor of the *U. S. R.R. and Mining Register*, will need no comment.

* * * * * * * * * *

"These are certainly wonderful discoveries, and judging from the character of the "ore," there can be no doubt that it exists in vast quantities. It was my good fortune already over one month ago to receive some of that which had been sent to Washington. About fourteen days ago I received a second lot for examination, and was also favored with a visit from one of the owners, who brought larger lumps and showed some bars of tin which had been melted from the ore, and also some copper which had been tinned with the product of such smelting operations. My specimens are *undoubtedly authentic.* They consist of a rock, composed of white feldspar (probably albite), hornblende and a small quantity of quartz. The albite and hornblende are present in variable quantities, sometimes the one, sometimes the other predominating. Ocular inspection did not show a trace of *tin*; concentration of the heavier portions, by grinding the rock and washing off the lighter, and the chemical examination of the heaviest did also show not a trace of *tin.* A very careful analysis and a crucible assay showed likewise the total absence of *tin.* The specimens which I received are, therefore, *no tin ore* at all, but syenite —a granite, in which mica is replaced by hornblende."

the Bothkamp observatory. White auroras gave five lines, red ones, seven. Among these was one of wave length 500·3, which Professor Barker says is apparently the same as that seen by him of wave length 502. In this note is given a table of all the lines hitherto observed and measured in the aurora. They number eleven in all, though no single observer has seen more than seven at once.

Coating with Zinc in the Wet Way.—According to M. Böttger, copper or brass may be given a firmly adherent zinc coating, by the following method :

Finely divided or powered zinc, in a non-metallic vessel, is covered with a concentrated sal-ammoniac solution ; this is heated to boiling, and the articles of copper or brass, properly cleansed, are introduced. A few minutes suffices to produce a firm and brilliant coating. The requisite fineness of the zinc is produced by pouring the molten metal into a mortar and triturating the same until it solidifies.

Absorbent Power of Red Phosphorus.*—M. Testini announces the fact that the red variety of phosphorus possesses, like porous carbon, the power of absorbing many substances without acting chemically upon them.

Iodine, sulphur, rosaniline, &c., are thus absorbed in quite perceptible quantities.

To show this property by experiment, the author shakes up a quantity of the powdered phosphorus, in the violet colored solution of iodine in bisulphide of carbon ; when, if sufficient material is present, the solution becomes colorless. A solution of rosaniline in ether is similarly affected ; and may be, in part, recovered again from the phosphorus unchanged, upon treatment with alcohol.

Temperature at Great Depths.—The temperature in the Mt. Cenis Tunnel, at a depth of 5000 feet below the surface, is about 27°C (80.6° Fahr.) This indicates a gradual increase of heat from the surface of nearly 1° Fahr. for every 100 feet of descent ; a fact which conforms very well with numerous observations of a similar nature made in various other localities.

Note on a Manganiferous Deposit from Spring Water.—At the last meeting of the British Association for the Advancement of Science, Mr. Emerson Reynolds read a paper† "On the Analysis of a Singular Deposit from Well Water," which recalls an observation of the writer of this communication. The deposit examined by Mr. Reynolds "consisted almost wholly of an oxide of manganese" arising "from the gradual oxidation of manganous carbonate, present in extremely minute proportion in solution in the water." In June of the present year the writer, (then Professor of Chemistry at Delaware College) completed an analysis of the waters from a supposed

* Nature, Oct., 1871.

†See abstract of this paper in *American Chemist*, October 1871, page 127.

mineral spring, situated about one and a half miles northward from the village of Newark, New Castle county, Delaware,—which for upwards of half a century have had wonderful medicinal properties ascribed to them. A quantitative examination showed a wine gallon of the water to contain only 7·08622 grains of dissolved matters, with the following composition: Ferrous carbonate, 0·50532; manganous carbonate, 0·21206; calcic carbonate, 0·95749; magnesic carbonate, 0·28742; potassic carbonate, 0·86402; potassic sulphate, 0·61573; potassium chloride, 0·06484; sodium chloride, 0·74893; alumina, a trace; silicic acid, 1·37050; organic matters, 1·42542 = 7·05173 grains.

The relatively large amount of manganous carbonate (amounting to 3 per cent. of the whole dissolved matters) appeared to be somewhat of a novelty, and led to the examination of the deposit from the spring. This deposit accumulates rapidly, is of a dark brown color, and when carefully dried at 100°C. contains 32.84 per cent. of manganic oxide, the remaining constituents being chiefly ferric oxide, organic matters, and water, with small amounts of calcic and magnesic carbonates. The spring issues from augitic rocks. The valuable therapeutic properties locally ascribed to the water must be regarded as imaginative rather than actual, unless indeed, the manganous carbonate is of some importance in such direction.

CHAS. P. WILLIAMS, *Director Mo. School of Mines.*
Missouri School of Mines, Rolla, Mo., Oct. 20, 1871.

Phosphorescence.—The phosphorescent substance in fishes is announced by M. Pauceri to be the fat; and its cause is declared to be the slow oxidation of the fat in contact with the air, the permeability of the skin allowing this process to go on without difficulty. The phenomenon ceases as soon as decomposition begins; it is equally prevented by the presence of fresh water or carbonic acid, while oxygen, it is said, intensifies it.

To Clean Vessels of Petroleum.*—Thin milk of lime is recommended by Dr. Stolba as an excellent material for cleaning glass or other vessels which have been used for keeping this oil. The lime forms with the oil an emulsion, and renders it easy, especially by the addition of a slight quantity of chloride of lime, to remove even the smell of petroleum. By applying the lime warm, its action is hastened.

* Dingler's Jour., July, 1871.

Thallium.*—In order to preserve the bright metallic appearance of the rare metal thallium, which oxidizes in the air with great readiness, a number of methods have been suggested, but all, it appears, were unsatisfactory. Some years ago, Böttger proposed the use of a concentrated solution of grape sugar, and he now announces that his suggestion has turned out well. The sole objection to this fluid being the formation, in the course of time, of a slimy sediment, from which the solution becomes turbid. The author, in searching about for a fluid which should be free from this objection, announces now that he has found that distilled water answers the purpose perfectly. It is necessary, however, that the water should first be thoroughly boiled to free it from air, and allowed to cool in a closed vessel.

He informs us that a mass of thallium fused beneath cyanide of potassium, and preserved under the conditions named, lost nothing of its brilliant lustre, even after three years.

A New Reagent for Ammonia.† Dr. Lex communicates a new test for ammonia which is asserted to be extremely delicate.

If a solution suspected of containing this substance is treated with phenol, and chloride of lime is subsequently added, a green coloration will appear; even where the quantity of ammonia is extremely slight, the reaction will ensue after the lapse of a few minutes.

Edible Earth.‡—Some of our readers may recall an item with the above title from Prof. C. W.C. Fuchs, which appeared some time since in this Journal,§ from which it appeared that the Javanese and the miners in some parts of Würtemberg were addicted to the curious habit of earth-eating. In relation to this subject, Dr. Göbel furnishes us now with the information that the inhabitants of a small village on the White Sea make use of an earth as an addition to flour in bread making. Its composition corresponds generally to that given in Prof. Fuchs' analysis.

The same author gives likewise the composition of an earth used by the natives of the district of Kirman in Persia for the same purpose.

This material consists mainly of salts of soda, and is readily soluble in weak acids. Since the inhabitants bake bread from flour

* Deutsch Indus. Zeit. 1870, p. 392.

† Ber. d. Deutschen Chem. Ges. iv, 809.

‡ Bul. Acad. St. Petersburg, from *Chem. News*, xxiv, 206.

§ See Vol. lx, 155.

which is fermented so as to become sour, the addition thereto of some of the powder of the mineral substance here alluded to, will have the effect of a kind of baking powder, and at the same time neutralize the acid.

New Products from the Oxidation of Carbon.*—A most important investigation from Prof. Schultze has just been announced, upon the 'products obtained in the direct oxidation of carbon with permanganic acid in alkaline solution. Besides oxalic and other acids, which were thus obtained in considerable quantity, the savant just named has succeeded in obtaining one which he called provisionally "anthraconic" acid, but which he at the time suspected, and subsequently, with the aid of Drs. Carstanjen and Baeyer, proved to be identical with mellithic acid. The importance of this splendid discovery to theoretical science will be duly appreciated by the laborers in the field of organic chemistry, and at the meeting of the scientific association at which it was announced, it was received with enthusiasm; while as the pioneer research in a field now opened for future fruitful discovery, its value to applied chemistry can hardly be overestimated.

The mellithic acid was obtained from various forms of carbon (amongst which was the graphite), and yielded, on distillation with soda-lime, benzol, and this, upon nitration and subsequent reduction, gave aniline.

A New Mode of Forming Perfect Crystals.—Prof. Schultze states that by the use of a gelatinizing liquid as a solvent, crystals of various substances may be obtained completely formed. In substantiation, a number of fine crystals of sugar, borax, etc., were shown, which had been grown in suspension in gelatin and other solutions.

* Ber. d. Deutschen Chem. Gesell., iv, 802.

Editorial Correspondence.

EXPERIMENTS ON THE EXPLOSION OF STEAM BOILERS.

To the Editor of the Journal of the Franklin Institute.

DEAR SIR.—Herewith please find a copy of the circular issued by the United Railroad Companies of New Jersey, explaining the nature of the experiments on the explosion of steam boilers as proposed by Mr. Francis B. Stevens. If possible please have the substance of it inserted in the next issue of the Journal with this letter. On Monday last, Nov. 20th, Mr. Stevens sent a messenger from New York with a letter to me, requesting that the Franklin Institute might be represented among those who would meet to see the experiments on Wednesday the 22d inst. He says: "As your Institute was the first, many years ago, to originate experiments of this nature, I know that I can, with propriety, ask this favor." The short notice prevented many of our members, who were informed, from accepting the invitation. The experiments tried on Wednesday were of the most interesting character, and will, no doubt, be fully reported in the Journal when you receive the necessary date from Prof. Thurston; but a few words should be said by those of us who were present, as to the general character of the experiments. In the first place, the preparations show with what an amount of energy and determination Mr. Stevens has gone into the work. He informed us that in two months time from the date of the appropriations, he had taken all the boilers described in the circular to the barren shore of Sandy Hook, through the open sea in stormy weather, and put them in place ready for the experiments. The first impression made upon my mind upon seeing the boilers in place was one of astonishment, at the amount of work done in so short a time. The boilers were all connected by feed pipes, and pipes to convey the pressure to the various pressure gauges used. The manner of arranging the various boilers and the care taken in the minute detail of connection show a method that cannot be too highly commended. That anything that is worth doing at all is worth doing well, is a good maxim, and this seems to be Mr. Stevens' idea in preparing for the scene of destruction which must follow the bursting of any, or all of these boilers; with no needless expenditure there seems to have been nothing neglected to secure the knowledge of results. That such experiments must be attended with danger no one can deny, but Mr.

Stevens seems to have thoroughly informed himself by careful preliminary experiments, carried to the limit of safety as indicated by hydraulic tests of the particulars of each boiler, as relates to time required to steam up, and consequently of the time when it should be advisable for the men employed to go away from the strained shells. To me there seemed something sad in the thought that these boilers, which had done such long and faithful service, were now to be torn asunder in the cause of science, and to end their existence in showing to the observant engineers what was to be learned by their destruction.

The first boiler experimented upon was No. 3, a return flue boiler of the same form as that of the Westfield, but smaller. This, intended to carry 40 lbs. of steam when new, now stood, after thirteen years use, the pressure of 93 lbs. without bursting; the many cracks in all parts of the shell under this strain show how uniform was the strength of the whole, and speak well for the design and workmanship. That it would not burst, seemed to be the prevailing opinion of all who saw it steamed up, as I know that in most cases the cracks increase in size in proportion to the pressure, thus forming safety valves for the pent up steam, and do not always permit an explosion to ensue. It would have been interesting to have seen what would have been the result had a large safety valve been suddenly opened, which would have been equivalent to the starting of an engine.

In the actual bursting afterwards of the slab described as No. 6, 6 feet long, 4 feet wide and 5 inches thick, stayed in the same manner as the water leg of the Westfield boiler, a curious phenomena was noticed. On the inside of the disrupted sheets, were found markings as regular as if made on a lathe, of curved lines, surrounding and starting as it were from every stay bolt. These markings were so distinct as to be capable of being transferred to paper pressed upon them. That these were lines of strain seemed to be the prevailing opinion of those who saw them. Hoping soon to see the reported results of the experiments which are to be continued from day to day, I feel sure that I express the opinion of Mr. Jacob Naylor, Mr. Henderson and yourself, who were with me on Wednesday, that the experiments promised much valuable coroboration, if not actual addition, to our knowledge on this subject.

Respectfully,

Coleman Sellers,

Pres't. Franklin Institute.

Civil and Mechanical Engineering.

INTEROCEANIC COMMUNICATION ACROSS CENTRAL AMERICA.

By Prof. J. E. Nourse, U. S. N.

(Continued from page 309.)

The apathy or, at times, virulent opposition of Spain to the improvement of the transit has been noted; the apathy of British authorities and capitalists has been, at times, loudly complained of by their own people.

The latest record against them is in the history of the Panama route. In 1845, Capt. Liot, of the British Navy, Colonial Sup't. of the Royal Mail Steam Packet Company, visited the isthmus to secure the construction of "a Macadamized carriage-road, tram-road, or a railroad, from Portobelo to Panama." The transit was still in its miserable state. "Merchandise was conveyed on mules, or on men's shoulders." The Company claimed the honor of having restored this communication across the isthmus,—a line almost abandoned since Spanish rule ceased. A canal was not now proposed; a railroad, even, was not seriously contemplated; but a Macadamized road was recommended, as the only project "likely, for half a century, to pay," California not as yet being opened.

The government of New Grenada highly favored the plan. Capt. Liot made a favorable report. The British Consul fully sustained him. But the home authorities proved wholly unwilling to afford any such "guarantees or immunities as might secure the Transit Company against undue risk." It was admitted that "stirring events in Mexico and California, and the impulsive agency of American enterprise, were hastening the solution of the question of interoceanic communication." But nothing could be done in England. While Liot's Report was getting into print, and the English were getting quite sure that no improved route would pay, three Americans—Chauncey, Stephens and Aspinwall—foreclosed the case by determining that the Panama Railroad should be built. Admiral Fitzroy said of it, "United States men only" could construct it. He had before urged his countrymen to remember that "the resources of the world were at the command of British capital." (Liots "Panama, Nicaragua

and Tehuantepec," London, 1849; Fitzroy on the Great Isthmus, Jour. R. Geog. Soc., Vol. 23.)

The conclusions to be derived from our narratives thus far seem to be fairly these:

I. From the earliest discovery of America, the riches of Asia stimulated strong desire for an easy transit; the problem has secured an historic grandeur; the search for an open westward passage lay along the whole continent from Alaska to Cape Horn. Even Virginia was explored: "The South Sea," says Bancroft, "was considered the ocean path to every kind of wealth. * * With singular ignorance of the progress of geographical knowledge, it had been expressly enjoined on the Virginia colonists to seek a communication with the South Sea by ascending some stream which flowed from the northwest. The *Chickahominy* was such a stream (!) Capt. John Smith, in ascending it, was captured by the Indians." (Bancroft, vol. i, p. 130.)

It is well known that the great Humboldt, on his visit to the New World, devoted a part of his labors to the investigation of some of the principal routes. His tabulated statement of these will be given in our next.

Three and a half centuries, indeed, have heard the yet unanswered whispers of the Secret of the Strait.

II. The selfish policy of old Spain—part of the policy of the age—suffered all improvement to be forgotten. They would have gladly passed their own galleons only through a natural strait, if it could have been discovered. But neither themselves, nor any other people, company or adventurer were to do anything to open up or improve a transit.

III. The New Republics have been more favorably disposed for improvement. They have been dilatory, inefficient, and incapable of effecting much themselves; but they have not been so blind as to fail to appreciate a route. They have been at times disappointed by the fault of others. In 1846, General Mosquera, President of New Grenada, issued favorable decrees, under the sanction of the National Congress, offering $3000 per annum to a foreign engineer (of Ponts et Chaussees), as superintendent, and providing a fund for his use for the improvement of the national roads. And they said, then, singularly enough: "After ten years of fruitless *expectation*, the govern-

ment is once more in a position to treat with parties who may desire to undertake the formation of an efficient line of communication between the Atlantic and Pacific Oceans."

IV. The English had until our day the best opportunities for opening up improvement.

They had for a long time vast capital uncalled for at home. They had and have the trade of western South America in their hands. A good transit, at any time, would have quickly trebled this as well as their Asiatic traffic.

V. Explorations in later times have not been infrequent, but singularly *unfortunate*. Generally they have not been properly equipped. They have not reached the field at the proper season to give time for thorough explorations before the floods of the rainy season utterly debarred their progress. Little permanent or hopeful result, therefore, has as yet been reached, except it be that certain routes (the fabled Raspadura, or such routes as would require four-mile tunnels) are known as impracticable. Time and money need not be wasted on them. Others—or rather districts in which others may yet be hopefully looked to—have, to this day, been but *partially* examined.

The Tehuantepec and Nicaraguan lines are known to be too long; harbors are wanting for them, and cannot be supplied. The Honduras and Costa Rican routes are those of known great elevations; the Panama route has no sufficient feeder necessary for a canal; the Atrato has no advantages of harbors or of shortness. *Darien* remains, inviting true exploration. This it has never had. Reconnoissances have been made; guesses have been framed; men have talked of crossing it. It remains to-day in the hands of the aborigines who freed themselves from Spanish rule a century ago; a land of mystery.

One of the strangest records in the history of our day stands against this same region of Darien; it is this: that three expeditions, representing the three most powerful commercial nations of the world and the three most interested in discovering this route, should find themselves about the same time in this Darien for the purpose of exploration, and yet should accomplish almost literally *nothing*.

This is the history of the visit to the Pacific side by the Virago, under Capt. Prevost, R. N., and to the Atlantic by the Scorpion and Espiegle; and, about the same time, by the Chimére, under the French Lieutenant Jaureguiberry; and the United States corvette

Cyane, under the ill-fated Strain. It is not, however, injustice to any of these to say, that lack of proper foresight and undue rivalry and haste to cross first, sufficiently account for this failure. It is consolation to know that this history, though seemingly the failure of three great nations, proves nothing against the desirableness of a well-executed, *thorough* survey. This, as all from Humboldt to Malte Brun have agreed in saying, should be on the Atlantic side chiefly, and of the whole cordillera.

What has been learned of the two routes explored by the U. S. Government in 1870 and in 1871, will be referred to under those routes, in geographical order.

Glance now, on the other side, at the *difficulties* of such explorations. Give full credit to the explorers—ardent, sanguine, prudent, energetic, enduring, yet unsuccessful. Fitzroy's sketch of the chief difficulties in the enterprise yet remains true.

Look, for a moment, at some of these difficulties, natural, political and financial:

I. The great isthmus bears upon its face an almost unbroken cordillera; Gisborne says an *entirely* unbroken chain.

There is a marked contrast between the American isthmus and the Isthmus of Suez. America here is a mountain ridge. Africa is an arid, sandy, longitudinal depression, of which more than one-half is on a level with or below the Red Sea and the Mediterranean. To cross Suez is to encounter scarcely an elevation of fifty feet. To cross Central America is to find elevations, in Honduras two thousand nine hundred feet, or in Panama—the line of the lowest-level as yet found—elevations from two hundred and seventy to four hundred and fifty feet. The summit ridge on the Panama Railroad is two hundred and eighty-seven feet above the mean tide level of the Atlantic.

If the two requisites for an easy route are, that there be but a reasonable elevation to be overcome, and that a good harbor be found at each end of the line, the isthmus seems to present this singularly formidable obstacle, that these two requisites cannot, so far, be discovered on the same line. If, for example, Caledonia Bay on the Atlantic, or Realejo on the Pacific, be a good harbor, over a large part of the intervening line the cordillera stretches her forbidding frown. Or, if a comparatively lowland route be thought open, by way of

Nicaragua, Panama or the Atrato, the route fails in the absolute requirements of a harbor. Greytown harbor has almost disappeared by the sitting up of the coast; the Atrato has insuperable bars; but the stormy seasons of the northers and of other fearful gales, demand a roadstead.

II. Suppose a practicable route to be found; that is to say, that, during the thorough survey which is still urged by the true advocates of a canal, the labors of the explorer shall permit him at last to show a veritable line, still the difficulties in the construction of a work must prove very formidable. They would bear yet more heavily on a canal than on a railroad. Some of them are:

1. Excessive wetness, owing to torrents of rain and continual showers between the periods of incessant downfall. This must be a serious impediment to the construction and preservation of the solid works of the canal.

2. Malaria, especially near the confluence of fresh and salt water under the influence of the tropical sun. It is by no means pleasant to observe how many adventurers, even as late as the French in 1861—'64, have advanced but a little way, when forced to return by the loss of men and their own breaking down. It is not only, however, that during the visits of explorers or rapid transit of passengers their health will be affected; we are to consider the lives of those permanently occupied in the construction of the work. Many an adventurous spirit must find life afterwards to be a burden, as did Strain, or be worn out by pestilential influences of the swamps, as was Stephens.

"Unquestionably," says Fitzroy, "the climate is a most formidable obstacle. There is no doubt that rain prevails about two-thirds of the year, even on the higher grounds of Darien, while it is no less certain that in the Gulf of San Miguel (where mangrove jungles abound, low muddy shores, and the great fall of tide exposes extensive mud banks) there is a continued succession of rains, more or less heavy, except during short intervals. Examine any travelers's accounts, read their narratives; they themselves bear witness to the undeniable fact, although in *general* terms they may say there is not *so much* rain, and it is not *so* unhealthy as has been supposed.

"It is possible that the great rise of tide on the south side of the isthmus may tend to purify the air on its shores, and this effect in such a place as San Miguel Gulf may be very beneficial."

3. The season in which extensive work can be done is lamentably short. Three or four months in the year—from December to April—is all that can be depended on in Darien; something more of the year in the more northern parts. Even the explorer has been driven off, as were Bourdiol and many others, leaving their work little more than begun.

This and other unfavorable points here named are, of course, well known to the travelers of the day. To the surprise of the writer, however, citizens and even officers have been met with apparently forgetful—if cognizant—of the isthmus season.

4. One more natural difficulty to be noted is the liability of the greater part of Central America to volcanic eruptions. Panama and Darien are comparatively free. Nicaragua commemorates her exposure by her State seal, the device on which is the picture of five active volcanoes.

III. The countless political revolutions in the States are a serious bar to effort. The best conceited plans and treaties have been suddenly cancelled by a revolution displacing the high contracting party before the ink was dry on the instrument of writing they had signed.

III. These natural and political hindrances themselves create the financial obstacles. Capital is always sensitive. Investments to be made in a distant enterprise, require a happy freedom from the most serious obstacles. The history of some schemes on the isthmus has been about this: Some few able capitalists become interested to carry forward an idea of so much worth as this canalization. They send a party of explorers who, coming late, stay long enough in the field to have their energy cooled by the climate and by apprehension of the natives,—a fear shown *now* by Com. Selfridge's experience to be groundless. They *think* they have surely seen a great depression of the mountain chain. They make a favorable report. They are succeeded by a second party, under tacit instructions to fall in with the route already formed. These get up a handsome report, with plates, maps and estimates for the company. Sufficient stock is taken. Then the "concession" is sold out to a third party, and the matter ends.

This kills, for a time at least, all efforts for a vigorous, thorough survey. "It has become difficult," says Mr. Bates, the Sec. R. Geo. Soc., "to awaken interest in the enterprise." The same must be

apprehended in our own country, if appropriations and labors of Government expeditions prove fruitless. And yet the true and successful time *will* come.

ON THE FLOW OF WATER IN RIVERS AND CANALS.

By J. Farrand Henry, Ph. B.

(Continued from page 328.)

Capt. Boileau, in discussing the effect of the wind upon the surface of the water in experimental canals, says:* "In the geometric lines representing M. Hennocque's observations, when a strong down stream wind was blowing, and also in two of those of M. De Fontaine, it is very remarkable that those lines, after being curved to a certain point, as if to give the maximum velocity below the surface, are inflected in the contrary direction under the influence of the wind, so as to bring the maximum to the surface." Thus, this effect of the sides is apparent even when a strong wind is blowing with the current, and carrying the maximum to the surface.

In other observations the data are seldom given with as much detail as those of Darcy and Bazin. But such as are at present accessible are as follows:

Dubuat. An experimental canal, about one foot deep, gave the maximum velocity from $\frac{1}{6}$ to $\frac{1}{8}$ below the surface.

Boileau. In an experimental canal, about two feet wide and one foot deep, it was from $\frac{1}{4}$ to $\frac{1}{5}$ the depth below the surface.

Hennocque. On an arm of the Rhine, where the depth was about eight feet, the maximum was about one-fifth the depth below the surface.

Baumgarten, on the canal du Rhone au Rhin, where it was about 45 feet wide, found the maximum below the surface, except for about three feet in the middle of the stream.

On the Garonne, Baumgarten observed the maximum to be generally at the surface; but in one section it was below for a portion of the river about 325 feet wide near the middle.

De Fontaine found the maximum on the Rhine, where it was about five feet deep, to be at the surface.

Racourt, in his velocity measurements on the Neva, found the maximum at the surface. The river at one point was 900 feet wide and 63 feet deep.

* Mesure des eaux courantes, page 311.

All these observations confirm the law deduced from the Darcy and Bazin observations, that when water is flowing in a channel with vertical sides, the maximum velocity will be found below the surface, when the depth is greater than one-fourth the width; and when the depth is less in proportion to the width, it will be at or near the surface; also if the sides of the channel are sloping, the depth may be one-third or one-half the width before the maximum leaves the surface.

In the Mississippi, the new theories of flowing water place the maximum velocity three-tenths of the depth below the surface.

As these observations are the only ones which do not conform to the general law, it will be well to examine them; particularly as the authors say:* "The method of conducting the field work and of computing the results is given in great detail, in order that it may be seen what degree of confidence the conclusions hereafter to be drawn from this material are entitled to."

On page 230 is the following: "As floats are compelled to pass through nearly the same paths when starting from a fixed station, and are consequently unaffected by the change in velocity due to the difference in distance from the banks, the principle was adopted of depending entirely upon the elaborated sets of observations from anchored boats. All the observations in each set being thus confined to nearly the same vertical plane, one great cause of error was practically eliminated. From the position of the boat, found by triangulation, the recorded gauge reading, and the known depths of the different parts of the river section, the depth of water in each vertical place of passage was readily determined."

It appears from this that the method of observing floats, so elaborately described on page 225,† was not used at all, at least for the determination of the velocities on which the formulæ are based: (although they say "that system was adopted for the observations both of 1851 and 1858,") but merely the time of passage of floats between the two stations was observed.

This, of course, greatly simplified the work; but they were obliged to assume that "floats starting from a fixed station are compelled to pass through nearly the same plane." How erroneous this assumption is has already been shown, and, therefore, in place of eliminat-

* Humphrey and Abbott's Report, page 221.

† *Ante*, page 225.

ing any of the errors of float measurement, it merely adds another to that list.

"It was evident that some combination of curves was necessary to reconcile discrepancies of observations. The first method adopted was to combine all curves where neither the depth of water nor velocity of river varied materially. * * The resulting mean curves are exhibited on figure XI, the numbers being shown in the following tables."* Let us first examine these tables. Here are recorded 2170 floats, of which 233 are interpolations, 1937 floats being observed.

On page 246 other similar tables are given, which were used for testing the formulæ deduced from the first set. These contain 447 floats, of which 109 are interpolated, making in all 2275 floats used in the computations.

In Appendix D, the velocities as determined at all of the stations on the river are given, and the number of floats there recorded exceeds 36000.

During the first year at Carrolton there were nearly 6500 floats passed, noted as at all depths; and though the remainder are given as at or near the surface, yet, as in these tables observations at several other places are recorded, we cannot be far wrong in assuming that there were at least 10,000 floats passed at all depths; especially as at Carrolton alone the work lasted over a year, and this amount would give an average of only fifty floats a day for 200 working days. Whether, if more than 2275 of these floats had been taken, the resulting curves and formulæ would have been changed, cannot be told; but probably these were considered to be the only reliable observations.

These floats give the velocity at 297 points on 69 verticals: and the means of the nine tables or groups in which they are arranged show the maximum velocity to be generally much below the surface, the resulting curves having a decided flexure toward the surface, as well as toward the bottom.

In Table VII these verticals are taken separately, the depth of the maximum velocity and the number of floats passed at that depth being given for each vertical.

The number of verticals in the first set of tables or series is 39, and in 23 of them the maximum velocity is at the surface or one-tenth of the depth below; in the second series, nearly half the verticals give the maximum near the bottom.

* Humphrey and Abbot's Report, page 230.

TABLE VII.

Depth.	First Series.		Second Series.		Total.	
	No. of Verticals	No. of Floats	No. of Verticals	No. of Floats.	No. of Verticals	No. of Floats
0	12	63	8	17	20	80
1-10th	11	46	1	2	12	48
2-10ths	5	33			5	33
3-10ths	3	20	1	3	5	23
4-10ths			4	9	4	9
5-10ths	2	22	1	3	3	25
6-10ths	5	30	1	3	6	33
7-10ths			6	18	6	18
8-10ths			6	15	6	15
9-10ths			2	5	2	5
Bottom	1	8			1	8
Sums	39	222	30	75	69	297

But, if we throw out those verticals where the maximum is at mid-depth and below, which must certainly be erroneous, there remain in the first series 31 verticals, of which 23, or ($\frac{3}{4}$) three-fourths have the maximum at the surface or one-tenth the depth below; and in the second series 14 verticals, 9 of which—two-thirds—show the maximum at or near the surface.

One of the verticals in the first series gives the maximum at the bottom, or rather one foot *below* the bottom, as it is recorded.

Thus, nearly all of these selected observations follow the general law deduced from the European observations; though the means of the groups in which they are arranged do not.

In 1869, very careful observations were made on the St. Clair and Niagara rivers, to determine, if possible, the law of change in the velocities near the surface and bottom. In the measurement of the velocities near the surface, the meter was suspended off the side of the boat, on a pole long enough to remove it from the retarding influence of the boat. The means of the observations near the surface are given in Table VIII.

These velocities are plotted in Figures 7 and 8, being represented by the circumscribed dots.

A free hand curve, shown by the full line, was drawn through as many of the points as possible; and the ordinates of this curve are given in the table.

TABLE VIII.

Depth below the Surface.	St. Clair River.		Niagara River.	
	Observed Velocities.	Ordinates of Curve.	Observed Velocities.	Ordinates of Curve.
Surface		0		0
1	3·607	0·025	2·924	0·015
2	3·651	0·040	2·943	0·035
3	3·651	0·055	2·965	0·045
4	3·662	0·065	2·956	0·057
5	3·689	0·075	2·985	0·070
6	3·676	0·070		
7	3·672	0·065		
8	3·644	0·055		
9	3·646	0·035		
10	3·601	0·020	2·989	—0·005
No. of Verticals	47		45	

In these rivers, as the table shows, the maximum velocity is about five feet below the surface, though the difference between it and the surface velocity is quite small. The mean surface velocity in these rivers was nearly three miles an hour; but in the St. Lawrence, where the current is only about one mile an hour, the surface velocity was often considerably greater than that five feet below; although, unfortunately, too few observations of the surface velocity were made to give it exactly. Thus, these great rivers connecting the lakes agree with the general law heretofore given; the slight retardation at the surface being probably due to the friction of the air. Therefore, in large rivers, we may consider the surface velocity in a calm time to be nearly the same as the maximum; while in narrow canals, especially when their sides are vertical, it may be considerably less.

One curious thing in regard to this descent of the maximum velocity was discovered by MM. Darcy and Bazin in their experiments.* This is shown in Table IX.

The covered canal was a tube, 0·80 m. wide and 0·50 m. high in the first case, and 0·48 m. wide and 0·30 m. high in the second. In both tubes the maximum velocity was found at the center. The cover was then removed from the tubes, and the water allowed to run through with a depth as nearly as possible equal to one-half the height of the tube.

Of these experiments M. Bazin says: "The half of the discharge of the first tube is 0·309 m. The open canal only discharges 0·307 m.;

* Récherches Hydrauliques, pages 176, 177.

but it will be noticed that the surface of the current did not quite rise to the center of the tube, being 0·042 m. below it. If we take this into account, we shall find, all the proportions being the same, that the discharge of the canal slightly exceeds that of the tube."

TABLE IX.

	Canal 0·80 m. wide		Canal 0·48 m. wide	
	Covered.	Open.	Covered.	Open.
	Meters.	Meters.	Meters.	Meters.
Height or depth of water	0·50	0·2458	0·30	0·1513
Inclination..................	0·00427	0·00430	0·00627	0·00600
Discharge....................	0·618	0·307	0·191	0·093
Maximum velocity.........	1·826	1·859	1 634	1·615
Mean do.	1·545	1·561	1·326	1·282
Maximum below surface on center vertical......	½ depth	⅙ depth	½ depth	0
Do. do. side vertical......		½ depth		⅓ depth

And of the second set of experiments he says: "The half of the discharge of the tube is 0·0955 m., or a little greater than that of the canal. The surface of the water in the latter rises above the axis of the tube 0·0013 m. Taking this into account, and also the difference in the inclination, we shall find an excess in the discharge of the tube, very small, it is true, but a result precisely the opposite of that before obtained. * * The comparison of the preceding results appears to demonstrate that in a calm time the resistance of the air has very little influence on the discharge."

But, notwithstanding the very small difference between the discharge of the tube and the canal, the maximum velocity in the first experiment descends from the axis of the tube to one-sixth the depth below the surface on the center vertical, and to one-half the depth on the verticals near the side.

M. Racourt measured the velocity of the Neva where it was covered with ice, thus forming a tube 900 feet wide and 63 feet deep. The observations were made by cutting holes in the ice, and letting down a ship's log.

The following were the measurements on the deepest vertical:

Velocity near the surface, . . .	1·91	feet per second.
" a little below the center, . .	2·58	"
" near the bottom, . . .	1·67	"

The maximum was found a little below the center of the deepest vertical; while in summer—when the cover was removed—it rose to

the surface. These experiments confirm the conclusions drawn from the observations on small canals, that the *locus* of the maximum velocity is due in part only to the resistance of the air, but mainly to the form of the channel in which the water is flowing.

(To be continued.)

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 322.)

Belting.—"A leather strap or belt an inch wide will sustain 1000 lbs. before breaking. I have, therefore, taken 8 per cent. of the breaking weight, or 80 lbs. to the inch, or about 400 feet to the H. P., as a tension that will not materially injure the leather for a long period by overstraining or stretching. This is used for single belts—main drivers only. A double belt will give one-third more equally well.

"As regards the velocity of belts, this subject admits of a wide margin. Ordinarily, counter-belts, where the centers are not more than 12 feet apart, will require 1000 ft. to H. P. per minute, and card and loom belts from 2000 to 3000 to H. P. per minute. When at the Nashua Co's mills I ran a 20 inch single belt 7200 ft. per minute, from a 14 ft. diam. to a 4 ft diam. pulley, which ran successfully on the 14 ft. diam., but the centrifugal force on the 4 ft. diam. pulley caused it to jump or fly from the surface and run a little uneven, owing to the uneven weight and thickness of the leather.

"I think it would have run well on a 6 ft. diam. pulley. When it was running 6000 ft. per minute it ran very satisfactorily indeed, and I could not have asked to run it better. From this experiment, I have come to the conclusion that 6000 ft. is as fast as a belt should run when the pulley is not over 4 ft. diam. Taking this as a basis of calculation, a 10 ft. pulley may run a belt 10,000 ft. per minute with safety. It is, however, seldom in practice that we should use such quick speed. Some three weeks since I commenced running a single belt 5400 ft. per minute,—the smaller pulley being about 4 ft. diam., which gives excellent satisfaction. I know of no definite rule for running belting; everything depends upon surrounding circumstances.

"A horizontal belt, running on not less than a 7 ft. diam. pulley, 50 ft. from centre to centre, and working side at bottom, will run well with 400 ft. to a H. P., the slack being taken up by its own

weight. The same belt, at an angle of 45°, will require 500 ft. to the H. P., and with a vertical belt it will be almost impossible to run it any length of time without a binder, (which of all things we most dread in a mill). I will now mention one law of belting that may not be known to you all, *i. e.*, the hug or adhesion is as the square of the number of degrees which it covers on the pulley, or in other words, a belt that covers two-thirds of the circumference of a pulley, requires four times the power to make it slip as it does when it covers one-third of the same pulley.

"Belts, like gears, have a pitch line, or a circumference of uniform motion. This circumference is within the thickness of the belt, and must be considered, if pulleys differ much in diameter and you must get a required speed.

"Owing to the slip, elasticity and thickness of the belt, the circumference of the driven seldom runs as fast as the driver. With two pulleys of equal diameters, one may be made to run twice as fast as the other without slipping, if you use an elastic belt of india rubber. I simply mention this to show the effect of elasticity in belts. As the power of a belt is as its velocity, it is well to run it as fast as possible to avoid lateral pressure, and consequently friction of the shaft."

Pulleys.—"One of the greatest objections to the fast running of shafting and belts is the want of pulleys properly constructed. My experience leads me to the conclusion that it is not safe to run a cast iron pulley 4 ft. diam., 400 rev. per minute., owing to the unequal shrinkage of castings in cooling and other imperfections. Running slow, the centrifugal force has but little effect; but as the centrifugal force is as the square of the velocity, it is not so easily overcome in rapid motions.

"If you make the rim of the pulley thicker, the centrifugal force increases with the thickness, and consequently nothing is gained by the extra iron. I have, therefore, substituted white pine felloes made of one inch boards, breaking joints for the rim, built on cast iron hubs and arms. The centrifugal force of material is as the specific gravity, and the specific gravity of cast-iron is thirteen times that of pine, hence the centrifugal force must be thirteen times greater; but the tensile strength of cast-iron is only two to one of that of pine, therefore the rim of a pulley made of white pine felloes will sustain from four to six times the centrifugal force of a rim made of cast-iron;

that is, the same diameter with white pine felloes will run more than double the velocity without being torn asunder. It is less likely to be broken by jar or blow, and is less than half the weight, and of course takes less power to run it. I have run a pulley made in this way, 16 ft. diam., 4 ft. wide, 90 rev. per minute for 18 months. I have just started another, 17 ft. diam., 62 inches wide, 100 rev. per minute, driving on to one made the same way 4 ft. diam. and running 425 rev. per minute. Both of these are working well. I am fully convinced that with quick shafting, *wood* must take the place of *cast-iron* for the rims of pulleys 3 ft. diam. and above.

"No. 2 section of Lawrence Manufacturing Co. has been running with gears, shafting, pulleys and belts, conforming as nearly as possible to the above rules, and is driving the shafting for 38,000 spindles (throstle, ring and mule) with the same amount of power as it formerly required for 19,000 spindles."—*Daniel Hussey, Esq., Lowell, Mass., from Proceedings of N. E. Cotton Manufacturer's Association, No.* 10.

NOTES ON SPRINGS.

By J. H. Cooper.

(Concluded from page 253.)

STEEL SPRINGS.

Rule 1*st.*—"To find elasticity of a given steel-plate spring: Breadth of plate in inches multiplied by cube of the thickness in one-sixteenth inch, and by number of plates; divide cube of span in inches by product so found, and multiply by 1·66. Result, equal elasticity in one-sixteenth of an inch per ton of load."

Rule 2*d.*—"To find span due to a given elasticity, and number and size of plate: Multiply elasticity in sixteenths per ton, by breadth of plate in inches, and divide by cube of the thickness in inches and by the number of plates; divide by 1·66, and find cube root of the quotient. Result, equal span in inches."

Rule 3*d.*—"To find number of plates due to a given elasticity. span, and size of plates: Multiply the cube of the span in inches by 1·66; multiply the elasticity in sixteenths by the breadth of the plate in inches, and by the cube of the thickness in sixteenths; divide the former product by the latter. The quotient is the number of plates."

Rule 4*th.*—"To find working strength of a given steel-plate spring: Multiply the breadth of plate in inches by the square of the thickness

in sixteenths, and by the number of plates; multiply also the working span in inches by 11·3; divide the former product by the latter. Result, equal working strength in tons burden."

Rule 5th.—"To find span due to a given strength and number, and size of plate: Multiply the breadth of plate in inches by the square of the thickness in sixteenths, and by the number of plates; multiply also the strength in tons by 11·3; divide the former product by the latter. Result, equal working span in inches."

Rule 6th.—"To find the number of plates due to a given strength, span, and size of plate: Multiply the strength in tons by span in inches, and divide by 11·3; multiply also the breadth of plate in inches by the square of the thickness in sixteenths; divide the former product by the latter. Result, equal number of plates."

"The span is that due to the form of the spring loaded. Extra thick plates must be replaced by an equivalent number of plates of the ruling thickness, before applying the rule. To find this, multiply the number of extra plates by the square of their thickness, and divide by the square of the ruling thickness; conversely the number of plates of the ruling thickness to be removed for a given number of extra plates, may be found in the same way." D. K. Clark –

"*Rubber car springs*, to resist actual compression and bulging, should be used in layers with intervening division plates; if used in bulk, should have retaining rings to prevent bursting.

The duration of spring depends, of course, on its quality. Pure rubber is of little use; it must be vulcanized. It is adulterated with plumbago, though in best springs as much as 40 per cent. foreign substances are used—principally sulphide of lead and soapstone."

Four inch diameter rubber car springs weigh 15·7 cubic inches per lb.; 7 inch diameter 16·75 cubic inches per lb. and 11 inches diameter springs, 17·57 cubic inches per lb.; whereof pure rubber weighs 28·8 cubic inches per lb.—*W. G. Hamilton, from Useful Information for Railway Men.*

"*Rule for the strength of Locomotive Springs.*

S = span of spring, in inches.
B = breadth of plate, in inches.
T = thickness of plates, in sixteenths of an inch.
N = number of plates.
L = safe load on spring, in tons."

$$L = \frac{B\ T^2\ N}{11{\cdot}3\ S} \qquad N = \frac{11{\cdot}3\ SL}{B\ T^2}.$$

—*Molesworth's Pocket Book for Engineers, London,* 1865.

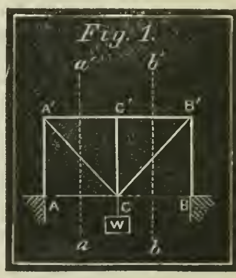
A SHORT THEORY OF THE TRUSS.

By J. P. Frizell, C.E.

A homogeneous beam, supported at its ends, resists the bending tendency of its own and extraneous weights by a strain of compression upon its upper fibres and of extension upon the lower. One of the first properties which the mind perceives in studying these internal forces, is, that the strain upon any fibre is effective in proportion to its distance from the centre, or, in more exact language, to its distance from a horizontal line through the centre of gravity of the section under consideration. This fact suggests the idea of giving increased effectiveness to the tensile and compression strains by placing the portions exposed to them at a considerable distance apart, and confining them immovably, with reference to one another, by ties and pillars or braces. To this combination we apply the term "truss."

To write an exhaustive treatise upon the truss, and one that might, with confidence, be submitted to the criticism of mathematicians, is a task far beyond the aims and abilities of the present writer. Nevertheless he conceives that a brief exposition of its chief properties by methods suited to the average comprehension will serve a useful purpose.

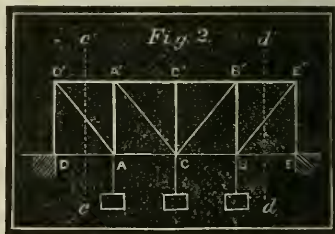
Let it be required to devise some means of supporting the weight W midway between the two fixed points A and B. Fig. 1 represents one of the methods by which it might be accomplished. Erect the pillars AA′ BB′ upon the fixed points; join their summits by the horizontal pillars or struts C′A′, C′B′, resting upon a third pillar CC′, and let the weight be supported by two ties CA′, CB′. To prevent any lateral motion of the frame, join CA, CB by ties.



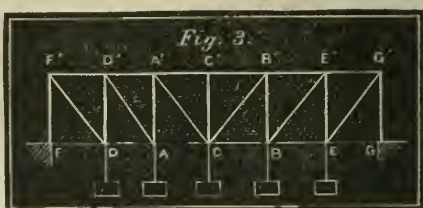
In considering this simple frame, there is no difficulty in estimating the strains upon each of the several members. The pressure acting vertically at C is composed of the extraneous weight W, together with the weight of the pillar C C′, and half the weight of the struts C′A′, C′B′ and ties CA, CB; or, drawing the vertical lines aa', bb' through the middle of each panel, the two ties CA′, CB′ sustain the weight lying between these lines. The tensile strain upon each tie is equal to one-half this weight multiplied by the secant of the angle

CA′ A. The compressive strain upon each strut C′A′ C′B′ is equal to the tensile strain upon the tie multiplied by the sine of the angle CA′ A, or equal to the horizontal component of that tension. Each of the pillars AA′, BB′ sustains one-half the weight W and one-half the weight of the structure, not including its own weight. Each of the fixed points A, B supports half the weight of the frame and its load W.

Now conceive each of the points of support to be removed a distance AD = BE = CA = CB farther from the centre. Erect the pillars EE′ DD′. Join D′A′, B′E′ by struts AD′ BE′, AD, BE by ties. Suspend additional weights equal to W from A and B. The portion AA′ B′B with its extraneous weights is now supported in precisely the same manner as the weight at C in the former case. Drawing *cc′*, *dd′* vertically through the centres of the panels AD, BE, the two ties AD′, BE′ sustain the weight between these lines, and each tie is under a tensile strain equal to one-half this weight multiplied by the secant of CB′B = BE′E. The pressure upon the struts C′A′ C′B′ is now increased by that on A′D′ and B′E′ respectively. The tension on CA, CB is equal to the pressure on A′D′, B′E′.



Repeating the process of removing the supporting points and supplying the additional parts and weights, we find as before, that each of the ties DF′, EG′ sustains half the weight lying between their centres, and its tension is equal to this weight multiplied by the secant of CB′B = EG′G. Each of the pillars FF′, GG′ supports half the weight lying between them. The pressures on C′B′ and B′E′ are increased by that on E′G′. The tension on CB is increased by that on BE.



We may pursue this process of removing the points of support till we form a truss of any desired length, loaded with any desired load, and the following general properties of the uniformly loaded truss will become apparent :

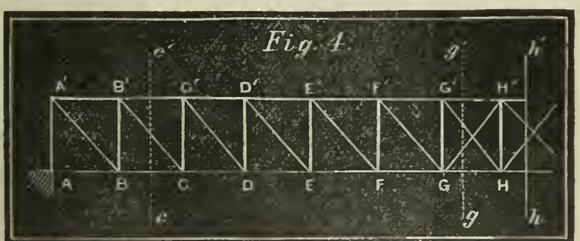
1. Each tie supports the weight lying between its centre and the centre of the truss, and is exposed to a tensile strain equal to the weight supported, multiplied by the secant of the angle between the tie and pillar.

2. Each pillar supports the weight lying between itself and the centre of the truss.

3. The pressure upon the upper chord at any point is equal to the sum of the tensions upon all the ties between that point and the pier, multiplied by the sine of the angle between the tie and pillar, or equal to the sum of the horizontal components of these tensions.

4. The tension upon the lower chord at any point is equal to the pressure upon the upper chord between the same two consecutive ties.

A truss constructed as shown in fig. 3 has all the bracing necessary to insure its stability with respect to a uniformly distributed load. No rational purpose would be served by ties joining the points C′B, B′E, E′G, that is, by what are usually termed counter ties. An increase of the load would bring no additional strain upon such ties, but would tend to loosen them if already screwed tight. The points connected by such ties tend to approach one another under the strain of a uniformly distributed load.



Let us now consider the case of an unequally distributed load. Suppose A to be one of the supports and the portion of the truss next A to be loaded, the rest of the truss being without load. Let A represent the pressure on the pier. *Any tie, as CB′, sustains a vertical pressure equal to A less the weight between A and c, the line cc' being drawn through the middle of the panel BC. That is, the

* The portion of the truss to the left of cc' is acted upon by three vertical forces: 1. Its own weight, acting downwards. 2. The force arising from its connection with the portion to the right of cc', also acting downwards. 3. The pressure, A, acting upwards. As these forces are in equilibrium, the second is equal to the difference between the first and third.

portion of the truss to the right of cc' tends to separate itself from the portion to the left of it by a force equal to A less the weight Ac. It is evident that a tie joining BC' would offer no resistance to this tendency.

As we recede from A toward the right, it is evident that we shall come to a point g, where the weight between A and g is equal to A: that is, where the tendency of the right hand portion to separate itself from the left hand portion is null. Beyond gg', as at hh', the portion to the left of hh' tends to separate itself from the portion to the right of it, and this tendency can only be met by ties, as GH', sloping in the opposite direction. The point g is sometimes called the neutral point, since the shearing strain at that point is nothing. It may with equal propriety be called the *breaking point*, since the strain upon the upper and lower chord, where it occurs, is a maximum. Thus the compressive strain upon the upper chord at g' is the sum of the horizontal components of the strains upon all the ties to the left of g'. The ties under strain to the right of g' sloping in a contrary direction, their horizontal components do not increase the compressive strain upon the upper chord, but serve in their aggregate to balance the pressure coming from the left of g'. For the same reason the tension upon the lower chord has its maximum value at g'. It is, therefore, at this point, if anywhere, that rupture would take place under the assumed load.

The breaking point shifts its position with every change in the distribution of the load. Thus, in an unloaded railroad bridge, the breaking point lies at the centre. A train enters the bridge, and the breaking point leaves the centre and approaches the train, reaches its extreme position, returns, passes the centre, reaches its extreme position on that side, and as the head of the train leaves the bridge, the rear not having entered, it returns to the centre. It describes the same cycle of motions while the rear of the train is crossing the bridge.

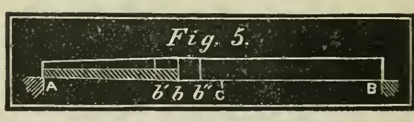
Since only the ties which descend toward the breaking point can be exposed to any strain, it follows that between the extreme positions of the breaking point a truss must be provided with ties sloping in both directions; outside of these positions it requires only ties descending toward the centre.

It is customary to speak of ties descending toward the centre as principal ties, and those descending from the centre as counter ties. I adopt this nomenclature, although it implies a misunderstanding of the function of what is called the counter tie; as if it served to coun-

teract, or oppose the action of, the principal tie. All ties are principal ties, or under strain, when the breaking point lies on the side toward which they descend, and counter ties, or out of use, in the contrary case.

It is usual to calculate the strength of a truss with reference to a load of uniform intensity applied to the whole or a part of the length of the truss.

Fig. 5.



Let AB represent a truss, b the breaking point, c the centre, w_1, the test load per linear foot. The maximum value of bc, or the greatest deviation of the breaking point from the centre, occurs when the test load extends from A to b. For, by the supposition, the total weight between A and b is equal to the pressure at A. Now any diminution of the loaded portion, as, for instance, by removing the load from b to b' will diminish the weight between A and b by $w_1 \times bb'$, but will diminish the pressure at A by $w_1 \times bb' \times \frac{Bb + \frac{1}{2} bb'}{AB}$. That is, it will make the weight between A and b less than the pressure at A, and will consequently move the breaking point nearer the centre. Again, by extending the loaded portion to b'', we increase the pressure at A without increasing the weight between A and b, and consequently move the breaking point nearer the centre. Since, therefore, we can not increase or diminish the length of the loaded part without diminishing the distance of the breaking point from the centre, we conclude that bc represents the maximum value of that distance.

This maximum value of bc may be determined thus:

Let w represent the weight of the truss per linear foot.
" w_1 " " " " load " "
" a " span in feet.
" x " distance Ab in feet. Then

$$(w+w_1)\,x = \frac{a\,w}{2} + w_1 x\,\frac{a - \frac{x}{2}}{a} \text{ or } x^2 + 2\,a\frac{w}{w_1}\,x = \frac{w\,a^2}{w_1}, \text{ whence}$$

$$x = \pm\, a\frac{w}{w_1}\left(\sqrt{1+\frac{w_1}{w}} - 1\right).$$

The negative value of x simply indicates that there is nothing in the conditions of the question to prevent the whole system from lying to the left of A, as well as to the right.

When the extraneous load is equal to the weight of the truss, foot

for foot, we have $x = a(\sqrt{2} - 1)$, or, the greatest deviation of the breaking point from the centre is 0·0858a, and the length of the portion requiring counter-ties 0·1716a, or about one-sixth of the span. When the load is twice the weight of the truss, foot for foot, we have $x = \frac{1}{2}a(\sqrt{3} - 1) = 0{\cdot}366a$, or, the maximum deviation of the breaking point from the centre is 0·134a. That is, the truss will need counter-ties a little more than one-fourth of its length. *When $w_1 = 0$, $x = \frac{a}{2}$, or the breaking point is at the centre. We may here recapitulate these general properties of the truss under an unequally distributed load :

1. The breaking point is a point which includes between itself and the pier a weight equal to the pressure on the pier.

2. Its maximum deviation from the centre occurs when the portion of the truss between it and the nearest pier is uniformly loaded with the greatest allowable load.

3. To find its maximum deviation from the centre, or least distance from the pier, we divide the maximum load per linear foot by the weight of the truss per linear foot, add one to the quotient and extract the square root of the sum, diminish the root by one, and multiply the result by the product of the span in feet, and the quotient obtained by dividing the weight of the truss per linear foot by the maximum load per linear foot. The result is the least distance of the breaking point from the pier.

The above are true independently of the arrangement of ties and braces. The following are true for the form of truss under consideration, viz*:* inclined ties and upright pillars. Tie reaching from top of pillar to foot of succeeding pillar.

4. Only that portion of the truss between the extreme positions of the breaking point requires counter ties.

5. Every pillar bears the weight of truss and load between itself and the breaking point.

6. Every tie descending *toward* the breaking point bears the weight of truss and load between the middle of the tie and the break-

* It might appear at first sight that x becomes infinite or indeterminate when w_1 equals o. Consider w_1 however, as very small with reference to w. In that case, $\sqrt{1 + \frac{w_1}{w}}$ is represented by $1 + \frac{1}{2}\frac{w_1}{w}$ with a degree of accuracy which increases as w_1 diminishes. When, therefore, w_1 becomes indefinitely small,

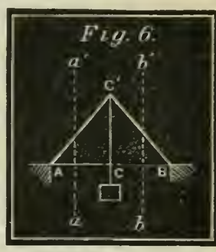
$$x = a\,\frac{w}{w_1}\left(1 + \frac{1}{2}\frac{w_1}{w} - 1\right) = \frac{a}{2}$$

ing point, and is exposed to a tensile strain equal to the weight sustained multiplied by the secant of the angle between tie and pillar. Ties descending *from* the breaking point bear nothing.

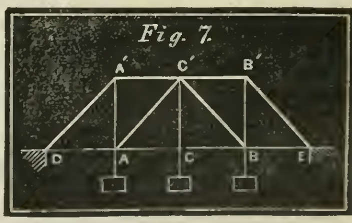
7. The compressive strain upon the upper chord at any point is equal to the algebraic sum of the horizontal components of the tensions upon all the ties between the point and either pier.

8. The tensile strain upon the lower chord is equal to the compressive strain upon the upper chord between the same two consecutive *acting* ties.

Let us now return to our original problem of a weight to be supported midway between two fixed points A and B. Fig. 6 shows another mode in which it might be accomplished. Erect the two inclined pillars AC′ BC′ and support the weight by a rod or tie C′C. To prevent any lateral strain upon the supports we must join CA, CB by ties. Draw the two vertical lines *aa′ bb′* through the middle points of the two pillars. Each pillar supports (at its middle point) half the weight included between these lines, and is under a compressive strain equal to the weight sustained multiplied by the secant of the angle BC′C. The tie CC′ supports the weight W and half the weight of the ties CA, CB. The tensile strain upon CA, CB, is equal to the compressive strain on the pillar multiplied by the sine of the angle CC′ A or the horizontal component of that strain, which is also equal to the pressure of the pillars against one another at C′.



Removing the points of support to D and E, adding the ties AA′, BB′, AD, BE, and the pillars A′D, B′E, A′C′, B′C′, and the extraneous weights at A and B, we have the weight of the portion AA′ B′B supported precisely as the weight at C was supported in the former case.



Proceeding in the same manner as in the case of upright pillars, we arrive at entirely analogous results for the form of truss shown at fig. 7, which, omitting all intermediate steps by reason of their similarity to what precedes, may be stated thus:

1. Only that portion of the truss between the extreme positions of the breaking point requires counter pillars.

2. Every tie bears the weight of the truss and load between itself and the breaking point.

3. Every pillar ascending *toward* the breaking point bears the weight of truss and load between centre of pillar and breaking point, and is exposed to a compressive strain equal to the weight sustained multiplied by the secant of the angle between tie and pillar. Pillars ascending *from* the breaking point bear nothing.

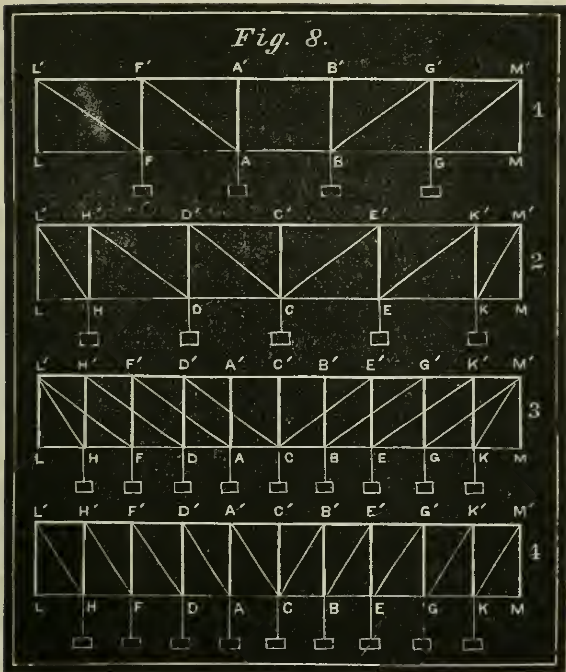
4. The tensile strain upon the lower chord at any point is equal to the algebraic sum of the horizontal components of the compressive strains upon all the pillars between the point and either pier.

5. The compressive strain upon the upper chord is equal to the tensile strain upon the lower chord between the same two consecutive *acting* pillars.

We have thus far considered the simple truss, in which the sloping member passes over only one panel. Let us now consider the system of multiple intersections, in which each sloping member embraces two or more panels. In doing so it will only be necessary to consider the system with upright pillars and sloping ties, since every principle demonstrable of this system has its corresponding truth in the system with inclined pillars and upright ties, arrived at by methods too similar to require repetition.

It is evident that, for any given span, there is a certain height of truss which will give the required strength with the least material; and also, that for any given height of the simple truss, there is a certain width of panel more advantageous than any other. It is, no doubt, within the resources of analysis to determine, in a general manner, the best values of these quantities. Yet a more ready and, all things considered, a shorter method, would be to find them for any given span by trial. For a given span let h be the height and l the width of panel so determined.

Let 1, fig. 8, represent a truss of 5 panels, each equal in width to 2 l. Suppose it to rest at L and M, and to sustain the equal weights W at each of the points F A B G. Let 2 represent another truss with 4 panels of the width 2 l, and 2 of the width l. Let it rest at L and M, and sustain the 5 weights W at H D C E K. The strains upon the several members of these trusses are readily calculated in accordance with the principles already explained, with these exceptions, the reasons for which will appear further on. The pillars composing the upper chord are to be calculated for a length l, and the weight of each of these pillars, as well as that of each of the upright end pillars, is to



be taken at half the weight of a pillar of double its strength. The absence of ties in the central panel at 1 need not embarass the reader. The weight of that panel is sustained in precisely the same manner as the weight at C in 2. Now suppose these two trusses to be united into one, as shown at 3, each pair of top chords, each pair of bottom chords, and each pair of end pillars being consolidated into one. Each of the several members in the compound truss bears the same strain as the corresponding member or members in the simple trusses. We can now compare these strains with those in the simple truss 4, of the same length, the same height, the same number of panels and bearing the same weights.

It will be noticed, first, that each upright pillar in 4, except the end ones, bears sometimes over twice as much as the corresponding pillar in 3; the portion of the weight on each pillar which arises from the weight of other pillars being more than twice as great in 4 as in 3. Any tie, as GK′ in 4, bears more than twice the weight of the corresponding tie GM′ in 3; but the tie GM′, acting at a greater angle with the vertical, will be under more than a corresponding strain. The

strains on GK′ in 4, and GM′ in 3, are respectively proportional to the weight sustained by each tie multiplied by its length. The quantity of metal in each of these ties is respectively proportional to the tension multiplied by the length. It is therefore proportional to the weight sustained multiplied by the square of the length. That is, supposing GK′ to bear twice the weight of GM′.

$\frac{\text{Weight of GM}'}{\text{Weight of GK}'^2} = \frac{1}{2} \frac{\text{GM}'^2}{\text{GK}'^2} = \frac{1}{2} \frac{h^2 + 4l^2.}{h^2 + l^2}$ For the case of $h =$ 2 l, this expression becomes $\frac{1}{2} \frac{2}{1{\cdot}25} = 0{\cdot}80$, or, the weight of GM′ would be 0·8 that of GK′. The end pillars and ties in 3 and 4, each support half the truss and load. The advantage, however, is in favor of 3, since that truss is somewhat lighter than 4. The top and bottom chords in 3 will be somewhat lighter than in 4 for the same reason.

It is evident that the strains in a truss with double intersections may be calculated, with reference to a partial as well as a uniform load, by separating it into two simple trusses.

In an entirely similar manner we may find the strains in a truss in which the sloping member passes over more than two panels.

The preceding examination shows an apparent advantage in the system of multiple intersections. It is only apparent, however, since it involves an assumption whose realization cannot be assured in practice, namely, the assumption that the maximum load with reference to which the truss is proportioned, will always rest equally upon each of the elementary simple trusses. In a railroad bridge, for instance, it is impossible to be certain that the heaviest trains will not sometimes be composed of cars of such length and distance between trucks, that the weight will rest wholly or in great part upon a single system of ties. To give due weight to this fact, it would be necessary to make each elementary truss much more than capable of sustaining one-half, one-third, &c., of the assumed load with suitable margin of security. Similar remarks apply in the case of carriage bridges, and, giving due consideration to this point, it does not appear to me that there is any advantage in the system of multiple intersections.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 318.)

Tenoning Machines.

We give in this number illustrations to a true scale of machines for tenoning, from the designs of the builders, Messrs. Ransome & Co., of London, Eng.

Fig. 1 is what might be termed a transverse cutting machine, the axis of the cutter shaft being at right-angles to the line of the piece to be cut. There are two spindles and two sets of cutters, as seen in the front elevation; the object being to cut from each side of the timber—meeting in the centre so as to prevent splintering.

The weight is one and one-half tons.

Machines of this kind, that are workingon a similar plan, have been very successfully adopted in some of our largest car shops, when the duplication of a large number of pieces is possible. There is, however, but one cutter-head used, which has a vertical instead of horizontal movement. Mr. Isaac Dripps, now Supt. of motive power of the Penna. Central Railroad, was the first to suggest machines of this kind in America, and although they have but a limited range of what we will term adaptation, their importance for special uses has been very fully demonstrated.

Fig. 2 is the standard machine for joined work, as manufactured by Messrs. Ransome & Co. It is of very simple and compact form. with the usual adjustments for spreading the cutter-heads, and is provided with a vertical spindle to carry "scribing" or "coping" cutters, it receives timber five inches thick and eighteen inches wide.

Weight about one ton.

Fig. 3 shows front and side elevations of a compound or double tenoning machine, intended for tenoning both ends of a piece at the same time. One-half the time of operation is saved by this arrangement, while the lengths are more accurate than can be attained with shoulder gauges. Some of the joiner-shops in Chicago have adopted this plan for tenoning sash bars and door framing with quite a saving in time, and the plan has much to recommend it in all cases where a large number of pieces are to be cut without changing.

Weight of the machine is two and one-half tons (English).

The cutter heads for tenoning machines have undergone many modifications; acting transversely to the grain of the wood, they form an exception to most other machines, and need what is known technically as "spurs" to sever the ends of the fibre before the shaving or cut is made.

The cutters also require a kind of shearing action, that is now gained by setting their faces diagonal to the line of the spindle, in which case the faces are planes. At first they were sprung into a kind of curvelinear form to accomplish the same end; in fact some makers yet make them so in England, which is the most to be wondered at when we consider that the effect is quite the same with the straight cutters, which can be made at a much less cost.

ON FEED-WATER TO STEAM BOILERS.

By Ign. Hahn.

Several articles appeared of late in this Journal relating to the use and abuse of steam boilers; the feed-water being a necessary component to it, allow me to make it the subject of this treatise.

Often it may occur that several sources are at disposition from which to draw the water supply; in such cases it is best to consider not only the cost of bringing the water to a certain point, but also the quality of the different waters, *i. e.* how much sediment each will leave on evaporation of equal quantities and what is the chemical composition of such residuum?

At first glance it will be admitted that two boilers of equal dimensions in every particular, of like setting and the same attendance, fired up simultaneously, will show quite a different evaporative power after say eight days service, when the feed-water supplied to the one, leaves for instance but one lb. of sediment for every 1000 gallons of water transferred into steam; while that of the second boiler deposits two lbs. per 1000 gallons.

In other words the boiler with the purer water will, after the eight days operation, require less coal per horse power per hour, than the other boiler; besides, the former will necessitate less stoppages for cleaning or blowing off, and remain a longer time in service before turning unsafe.

But, as already stated, it is not merely the quantity of incrustation. No! also its quality, the chemical composition of the water asks for its share of attention; because when one kind of water contains,

IN EVERY 100,000 PARTS (BY WEIGHT) OF THE WATER ARE :

	I.	II.	III.	IV.	V.	VI.
Chloride of Calcium, . .	0,12762	0,42072	1,64200	0,72260	0,86960	1,02400
Sulphate of Lime, . . .	0,14008	0,59330	0,25500	1,44550	0,17243	0,00680
Carbonate of Lime, . .	1,81766	4,97969	2,26100			
Carbonate of Magnesia, . .	0,59724	2,50740	1,28700	0,50438		
Sulphate of Magnesia, . .					0,32400	0,34500
Sulphate of Iron, . . .				0,53148	0,85500	0,22800
Carbonate of Iron, . .	0,33690	0,93377	0,10440	0,29043		
Carbonate of Manganese, . .		trace.				
Carbonate of Zinc, . .		trace.				
Sulphuric Acid (free), . .					0,76257	1,
Silica, ...	0,18500	0,42000			1,95000	0,63000
Organic Matter, . . .	2,00000	1,72328	1,53672	1,52769	16,23740	19,28000
Residuum left on evaporation, .	5,1000	11,8550	7,0909	5,2000	21,3000	23,3000
Mechanical impurities likely coming into boiler, . . .	0,3250	1,0500	0,3500	1,1500	1,2300	2,6500
Total Sediment, . . .	5,4250	12,9050	7,4409	6,3500	22,5300	25,9500

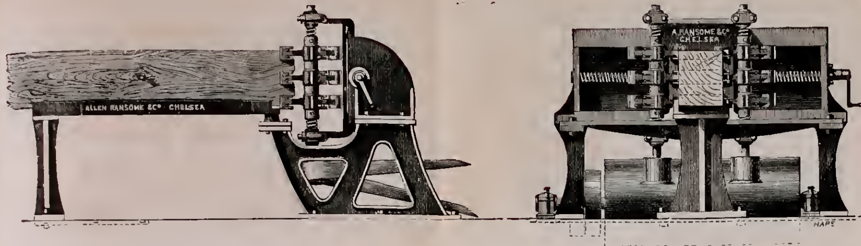


Fig. 1.

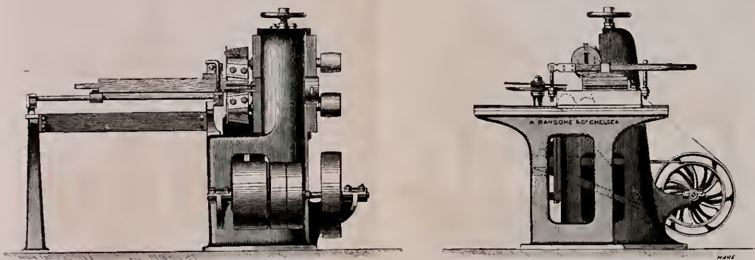


Fig. 2.

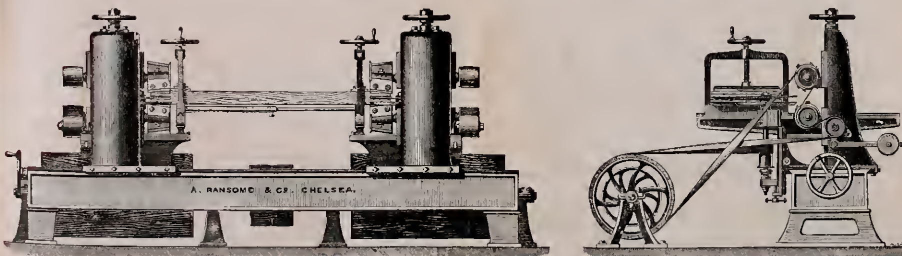


Fig. 3

for example, free sulphuric acid, the other kind not, then the employment of the latter would be more advisable, even though it may leave 50 or 100 per cent. more of residuum in the boiler.

The case where but one source of water can be relied upon, and that water acting detrimental on the metal of the boiler, will be spoken of hereafter.

As an illustration of the aforesaid the following series of analysis, made by the writer hereof, are entered; in which No. I and II are analyses of water* from Franklin Furnace, Sussex Co., N. J., taken July 8, 1871, namely:

No. I from Black Brook, taken at old dam, about half a mile above the mouth of this brook into Wallkill creek (low water stage).

No. II from Wallkill creek, at old dam near Catholic Church (low water stage). No. III, IV, V, VI and VII represent analyses of Roaring Brook water, from or near Scranton, Luzerne Co. Pa., *i. e.*:

No. III taken June 22, 1871, about 600 yards above mouth of Dunmore creek (low water). No. IV taken June 28, 1871, at dam about half a mile below mouth of Dunmore creek (low water). No. V taken June 28, 1871, at dam immediately above upper rolling mill of the Lackawanna Iron and Coal Co. (low water). No VI taken June 28, 1871, at dam just above blast furnaces of the Lackawanna Iron and Coal Co. (low water). No. VII taken July 20, 1871, at same place as No. IV, but at highest water mark known for years past.

The mechanical impurities of the water of analysis No. VII have the following composition:

Silica (sand), . .	76,0330	per cent.
Sulphuric Acid, . .	1,5990	"
Protoxide of Iron, . .	4,8964	"
Alumina, . . .	6,1315	"
Lime, . . .	7,8230	"
Magnesia, . . .	2,9590	"
	99,4419	

(To be continued.)

Mechanics, Physics and Chemistry.

THE CHEMICAL THEORY OF THE VOLTAIC BATTERY.

By J. P. Cooke, Jr.

MAGNETISM.

5. *Polarity.*—Manifold phenomena suggest the inference that, in many cases at least, the molecules of matter are to a greater or less degree polarized, and by this term is simply meant that they possess individually those attributes with which we are all familiar in the masses, and which are peculiarly prominent in the phenomena of magnetism and electricity. A brief summary of the characteristics of the polar condition as thus manifested will greatly facilitate a clear conception of our theory. A common magnet, which is simply a bar of steel magnetically polarized, presents the following characters:

6. *Magnetic Force.*—A magnetized bar has the power of either attracting or repelling any masses of matter which are similarly polarized, whether the polarity be a permanent condition of these bodies or only temporarily induced in them by the presence of the magnet.

7. *Magnetics.*—Only a few materials are susceptible of magnetic polarity to any great degree, and therefore are acted on by ordinary magnets. These are iron in its various conditions, a few of its compounds, together with the two allied metals—nickel and cobalt. Many substances, however, are affected to a slight extent by very powerful electro-magnets.

8. *Magnetic Poles.*—The magnetic virtue appears to reside chiefly at the two extremities of a polarized bar, which are called the poles of the magnet. If the magnetized bar is poised or suspended so that it may turn freely, it always takes a fixed position, in which the line connecting its poles is parallel to what is called the magnetic meridian —a slowly shifting direction at any given point on the earth's surface, but one which in low latitudes is approximately parallel to the geographical meridian. Since the same end of the bar always points north or south, it is evident that there is a difference between the poles, and they are accordingly distinguished as the North and South Poles, taking their names from the poles of the earth, towards which they respectively point.

9. *Similar poles repel each other, and dissimilar poles attract each other*, the force varying directly with the strength of the poles, and inversely with the square of the distance. In all cases

$$F = \frac{M\,M^1}{D^2}$$

where M and M^1 stand for the strength of the two poles, and D for the distance between them.

If two bar magnets, of equal size and strength, are placed side by side, so that the unlike poles are adjacent, they will tend to neutralize each the other's effect; but, if the like poles are contiguous, the compound bar will exert a greater magnetic force than that of either of the bars alone, thus showing that the two opposite poles are the compliments of each other.

10. *The Poles Inseparable.*—The opposite magnetic poles are always associated on the same magnetized body. They may be very irregularly distributed, as in the familiar phenomena of the multiple poles of a loadstone (fig. 1), or the consecutive poles of a steel bar when not uniformly magnetized (fig. 2); but in all cases the sum of all the north polar forces is exactly equivalent to, and would therefore exactly neutralize, the sum of all the south polar forces.

11. *Magnetic Elements.*—When a magnetized bar is broken, the two halves are each perfect magnets, and the same is true however far the subdivision is carried, the relative position of the new poles thus developed being that indicated in fig. 3. Moreover, when

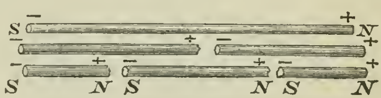


Fig. 3.

the parts are bound together, the resulting compound bar is found to be uniformly magnetized, with only two opposite poles, like the original magnet. Hence we conclude that the magnetism of the bar, as a whole, is simply the resultant of the polar conditions of its individual molecules, and that they are the ultimate elements of magnetic energy. The polarized structure of the bar may be represented conventionally as in fig. 4.

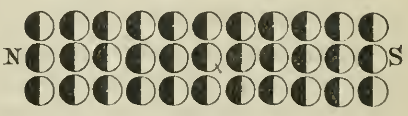


Fig. 4.

12. *Magnetic Induction.*—Any body susceptible of magnetic polarity, when brought near a permanent magnet becomes polarized by virtue of the presence of the neighboring poles, or, to use the ordi-

nary phrase, becomes magnetized by induction. The distribution of the polarity depends on various conditions, but in all cases those parts of the body nearest to the poles of the magnet become poles of the opposite kind, and the resulting attraction is merely a phase of the universal principle already stated (§ 9). Magnetic attraction is invariably preceded by the polarization of the body attracted, and hence, in the familiar experiment represented in fig. 5, the key, the nail and the tack are all for the time being as truly magnets as the steel bar which in the given case imparts the polarity.

When magnetism is induced in a homogeneous mass of very soft pure iron, the body instantly acquires the maximum degree of polarity which, under the conditions, the magnet is capable of imparting, and as suddenly loses this polarity the moment it is withdrawn from the sphere of the magnetic influence. Moreover, the distribution of the polarity depends wholly on the size and shape of the mass, and its position with reference to the magnet. It is quite different, however, if the material consists of hardened steel. The body then acquires magnetic polarity only slowly, and, under the same circumstances, never attains it to an equal degree, but the condition, when once acquired, is in a great measure permanent. Furthermore, the magnetism is imperfectly and irregularly distributed, and hence the difficulty of magnetizing uniformly large steel bars, and the various refined methods which have been devised for the purpose.

13. *Coercive Force.*—According to our theory, the induction of magnetism in a steel bar depends on the polarization of the individual molecules; and, since the polarity spreads so slowly and so unevenly through the metal, it is important to bring the magnet as near as possible to every molecule, by rubbing it many times successively over the whole extent of the surface, the slight jars produced by the friction greatly facilitating the change. When a steel bar has thus acquired the maximum degree of polarity it is capable of retaining, it is said to be saturated. Under the influence of a powerful magnet the polarization of such a bar may be frequently raised far above the point of saturation, but the moment the inducing cause is withdrawn all the excess disappears. The loss of polarity, like the assumption of it, must be a molecular effect, and that resistance in each molecule of the steel which, in some unknown way, tends to preserve the polar condition, we call the coercive force. In the molecules of soft iron there is little or no coercive force, and hence in bodies of this mate-

Fig. 1.

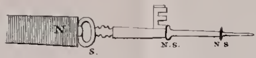


Fig. 5.

Fig. 2.

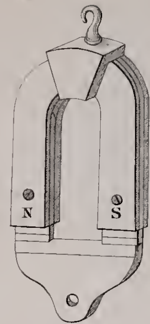


Fig. 6.

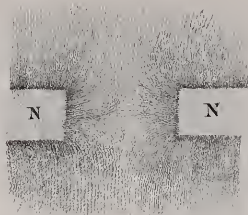


Fig. 9.

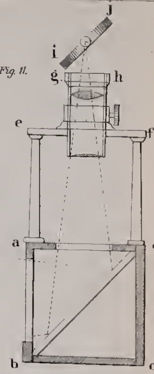


Fig. 11.

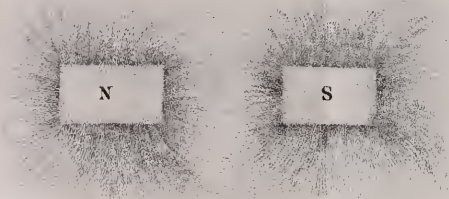


Fig. 7.

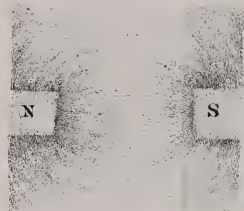


Fig. 8.

Fig. 10.

Jas. Mc Guigan Lith. Phila.

rial magnetic polarity is always dependent on some external cause; but soft iron readily yields to the magnetic influence, and assumes at once the maximum degree of polarity which the cause is capable of producing. In the molecules of steel, on the other hand, the coercive force is greater the greater the hardness of the metal; but then they assume with proportionally less readiness the polar condition, and the mass becomes, under the same circumstances, less strongly magnetic. In making a magnet, therefore, we have to consider not only how much polarity the metal can retain, but also how much can be imparted to it, and the best result is reached when these opposite conditions are most nearly balanced.

14. *Induction not a Transfer of Energy.*—In the process of magnetizing a steel bar, and in all cases where magnetic polarity is induced, the magnet employed suffers no loss of energy, but, on the contrary, may gain in power by the reaction of the newly polarized material. The effect of the "keeper" on a horse-shoe magnet is a remarkable illustration of this point. A horse-shoe magnet is simply a bar of magnetized steel, so bent that the two poles can be applied to the opposite ends of a much shorter bar of soft iron, which is called the keeper. The two poles, acting in concert on the same soft metal, impart to it a high degree of polarity, and this mass of polarized iron, reacting on the magnet, serves not only to "keep" up its polarized condition, but may even raise it far above the point of saturation of the steel. In all such cases, however, the moment the keeper is withdrawn the magnet falls back to its normal state.

A horse-shoe magnet, with its keeper attached, as in fig. 6, forms what is called a closed magnetic circuit, and, for the reasons already intimated, the force with which the magnet holds the keeper is far greater than twice the force which could be exerted by either pole acting singly.

If we place in contact with a powerful magnetic pole one end of various iron bars of the same quality and size, but different lengths, we shall find that the strength of the pole induced at the opposite end diminishes with the length of the bar. If, next, we take bars of the same quality and length, but different sizes, it will appear that, within certain limits, the pole is the stronger the larger the size of the bar; and, lastly, if we experiment with bars of the same dimensions, but different qualities, it will be seen that the strength of the pole increases with the softness of the metal. The extension of magnetic polarity through an iron bar is merely an effect of induction from

molecule to molecule in a uniform mass of easily polarized material. In this respect it resembles electrical conduction, but it differs from this allied phenomenon in so far as there is none of that transfer of energy along the lines of polarized molecules which chiefly characterizes a current of electricity. As has been stated, many substances are susceptible of magnetic polarity to a slight degree, but only the three metals named above are capable of transmitting the polarity to a marked extent, and this power is greatly diminished by the least impurity, which increases their hardness. Soft iron is by far the best magnetic known, but even in the softest iron bar, when united to the strongest magnetic pole, the effect is insensible at the distance of a few feet. Coercive force is obviously directly opposed to the transmission of magnetic polarity. Heat also lessens the susceptibility to magnetic polarity, and at a high temperature all traces of it disappear.

15. *Diamagnetics.*—In the ordinary experiments on magnetic induction the effect is produced through a layer of air, but the polarizing power of a magnet is exerted equally well through glass, copper, zinc, paper, wood or any other non-magnetic material. It is a familiar experiment to show that a horse-shoe magnet attracts its armature as strongly through a screen of glass or of pasteboard, as through an equal thickness of air. Materials through which magnetic induction is thus exerted without sensibly modifying their condition are called diamagnetics. Through magnetics the polarity is also transmitted, as we have seen, by induction from molecule to molecule; but in such cases we have evidence that the intervening material is throughout in a similar polar state. Moreover, there appears to be an essential difference between magnetic bodies of all kinds and the diamagnetics; for small masses of any diamagnetic material are repelled from either pole of a powerful electro-magnet, while even the feeblest magnetics are attracted under like conditions. So, also, a diamagnetic needle (made of bismuth, antimony or phosphorus, for example), when suspended between the poles of such a magnet, points not to the poles, but places itself on a line perpendicular to this axial direction, a position in which all its parts are at the greatest possible distance from the two equally repellant poles. It is probable, however, that in all cases of magnetic induction the polarity is transmitted step by step through the intervening molecules of the etherial medium with which all space is supposed to be filled, and, if so, we should expect that the material of the diamagnetic would modify to

some extent the result; but our knowledge on these points is as yet very limited.

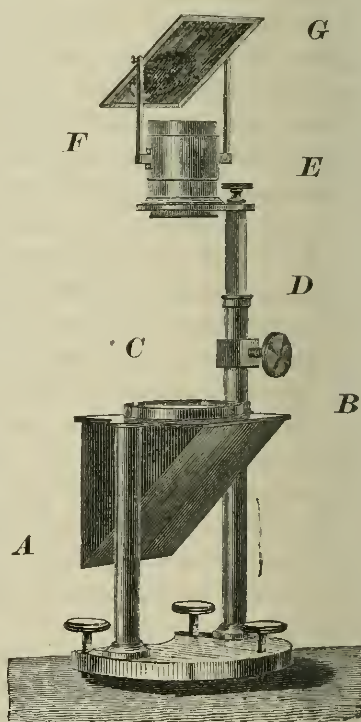
16. *Magnetic Field.*—An advantage is frequently gained by studying the phenomena of magnetic induction from a somewhat different point of view. Every magnetic pole may be regarded as modifying the conditions of the space around it, and the region within the sphere of the polar influence is called the magnetic field. This field, again, may be regarded as crossed by lines of magnetic force, which all centre at the pole. If the pole were a single point, and completely isolated, these lines would all be the radii of the sphere, having its centre at that point; but, as every magnetic pole is a mass of polarized material of a definite size and shape, and is always associated with its opposite, the relations of the lines is far less simple, and the direction at any one point is the resultant of the many polar forces acting at that point. This direction can be determined experimentally by means of a small magnetic needle, which at once assumes the direction of the lines of magnetic force at the point where it is suspended, and the lines in any section of the field can be most distinctly mapped on a plate of glass by means of iron filings sprinkled over its surface. The glass having been so placed above the magnet as to form the required section of the field, it will be found, on tapping the plate, that the particles of iron at once arrange themselves along the lines of force. Each of these particles becomes, in fact, a magnetic needle, which readily turns on the smooth surface of the glass. In fig. 7 we have a representation of the result when the plate rests directly on the two poles of a horse-shoe magnet. When the plate rests on a single pole of a bar magnet the lines diverge as radii from that centre, and by opposing to each other either like or unlike poles, of the same or different strength, various associations of curved lines will be formed, showing what complicated effects may result from the combined action of the two polar forces. The curves shown in fig. 8 were obtained with two equal and unlike poles, and those of fig. 9 with two equal and like poles. Lastly, the effect represented in fig. 10 was obtained by placing near a single pole a small piece of soft iron. The polarity of the small bar and its reaction on the magnet is here distinctly exhibited, and the effect will be more evident if these curves are compared with those at either end of the bar magnet on fig. 7.*

* These phenomena can be most beautifully projected by means of the apparatus exhibited in fig. 11. The wooden box, *a b c d*, is about ten inches cube, and has a circular aperture in front seven and a half inches in diameter, which

receives the tube of the condenser of a magic lantern. A diagonal partition, *b d*, supports a plate glass mirror, placed at an angle of 45° to the front of the box, and measuring nine by six inches. In the cover, *a d*, is inserted a small "light" of plate glass, about six inches square. Above the box is fastened, by four "uprights" at its corners, the board *e f*, which supports a common photographic camera tube (portrait tube, whole plate size). On the upper rim of the tube rests a brass collar, *g h*, to which is fastened the small plane reflector, *i j*. This last should have a good optical surface, but a common plate glass mirror will answer every purpose. The camera tube must bring to a focus on the screen the image of the glass plate, at *a d*, and hence the height of *e f* above *a d* should correspond to the focal length of the tube, which should be provided with rack and pinion for adjustment. The iron filings are sprinkled on the glass plate at *a d* with a small fine sieve, and the surface is then covered with a second plate of thin glass. This is best set in a shallow frame, to prevent it from coming in contact with the lower plate, and also partially coated with black paper, leaving only a circular aperture about three inches in diameter, which cuts off the chromatic edge of the circular image. The magnet is next placed upon the upper plate, and when all is ready the cover of the box is gently tapped. The curves at once take form on the screen, and the effect is almost magical. The same apparatus can evidently be used for projecting a great variety of effects which can only be exhibited on a horizontal plane.

If the condenser of the lantern is at least seven inches in diameter, the simple apparatus just described will be found to give perfect results, and it can be made, by an ordinary mechanic, with materials which the art of photography has rendered very common. It, moreover, has the great advantage of not requiring delicate adjustments. But with a smaller condenser the section of the cone of light made by the glass plate at *a d* would not be sufficiently large. This difficulty, however, can be remedied by using, in place of the glass plate, a plano-convex lens, having the same diameter as the condenser, and a focal length about equal to that of the common tube. A lens so placed forms, indeed, a part of the condenser, and nearly its whole surface can be illuminated; but the several lenses must then be accurately centred, and the construction of the apparatus requires the skill of a philosophical instrument maker. A beautiful instrument of this sort, devised by Professor Henry Morton, of Hoboken, and made by Messrs. Hawkins & Wale, of the same place, is shown in fig. 12.

Fig. 12.



CONTRIBUTIONS TO THE SUBJECT OF BINOCULAR VISION.

By Prof. Chas. F. Himes, Ph. D.

(Continued from page 348.)

PRODUCTION OF STEREOSCOPIC EFFECT BY MEANS OF THE PICTURES, WITHOUT THE AID OF AN INSTRUMENT.

Since pictures can be obtained corresponding to the retinal impressions in all particulars except size, as those of the frustum, fig. 6, it seems reasonable to expect that, if these pictures should be presented to the eyes in such a way that each should view the one proper to it, the conditions essential to relief would also be present, and the object represented should and in fact would consequently appear in relief.

This interesting fact was undoubtedly first established by Professor Wheatstone, in 1838, although much has been written by Sir David Brewster to detract from his credit in this respect. As it is unnatural, or rather contrary to unvarying habit, to look at one point with one eye and at another point, a few inches to the right or left, with the other, as would be necessary when each eye should view the half of the stereograph proper to it, Professor Wheatstone contrived an instrument to aid the eyes in so doing. And since, by its aid, two plane drawings were caused to present an appearance of solidity, he called it a Stereoscope, a name of Greek derivation, indicating this power to "see solidity." His instrument has been supplanted by others more convenient for ordinary use. The explanation of the instrument will be more easily made after the consideration of the methods of presentation of the pictures to the eyes so as to produce relief without the aid of any instrument, In this case a difficulty of complex character is encountered, which can, however, according to the experience of the writer, be very readily overcome by most persons, with very little patience and practice.

There is a constant habit in all individuals, from the earliest notice of objects, to look at the same point of an object with both eyes at the same instant, or to turn the optic axes upon the same point. If, therefore, a stereograph be held up before the eyes, both will look first at one and then at the other, and it will be found difficult to direct the right eye to its proper picture and the left eye to its picture, or to converge the optic axes to a point far beyond the plane of the point observed. Thus, in fig. 5, in which a b c d and a' b' c' d' represent the binocular pictures, and R and L the right and left eye respectively, when L observes the point a of its picture, R turns its axis, by force of habit, to

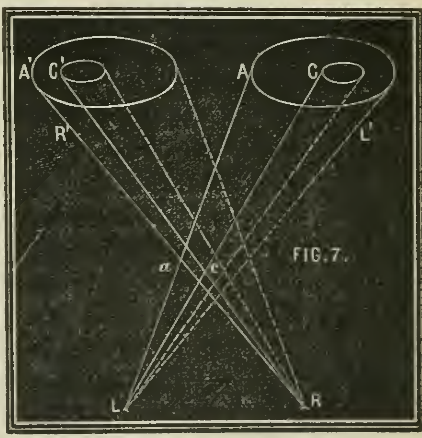
the same point, instead of to the corresponding point a' of its picture, and, if its axis should be turned to a', the axes would be convergent upon A, beyond. But the violation of this habit does not constitute the whole difficulty. The optic axis is not only directed to the point to be seen distinctly, but there is, at the same time, a focal adjustment of the eye to that point. When an object at the distance of 10 inches appears distinct, another at the distance of 20 inches will appear indistinct. When, therefore, the optic axes are converged upon a point observed, the eyes are unconsciously accommodated for distinct vision at the distance of that point. These consensual movements of convergence of the axes, and accommodation of the eyes to the same point, invariably accompany each other. In the attempt to view the stereograph, so as to obtain appearance of relief, a demand is made to separate these invariably accompanying movements, namely, to adjust the eye to see distinctly the points in the plane of the pictures, and to converge the axes to a point more remote. Thus, in fig. 5, when R is adjusted to a', and L to a, A will be the point of convergence of the axes.

The following method will be found to aid most persons in acquiring the power to dissociate these operations of convergence and adjustment, and to cause the pictures of an ordinary stereograph to combine, to form a clearer, more exquisitely beautiful figure in relief than can be obtained by aid of an instrument: Fix the eyes upon a distant object, in a remote part of the room will answer, and gradually introduce a stereograph about 18 inches from them. Four indistinct pictures will generally make their appearance, since each eye will see the two, but gradually the two interior ones will approach each other, and finally coalesce and produce the appearance of relief; but, although the relief will be unmistakable, there will be an indistinctness about the object, a hazy, atmospheric effect, which in some cases clears up almost instantaneously, and in others more gradually. just as the habit of convergence and adjustment may happen to be overcome suddenly or gradually, and the eyes be permitted to accommodate themselves to the points of the pictures observed whilst the axes remain converged on the remote points.

If, instead of the photographic pictures, two circles, about half an inch in diameter, or two wafers, be substituted, the experiment will generally prove easier, especially if their centres are not more than $2\frac{1}{2}$ inches or less apart. This is probably due to the fact, in the first place, that there would be less about them to invite that involuntary

scrutiny by the eyes, which would render it more difficult to hinder their concert of action, and, in the second place, if the circles were nearer together, the point of convergence of the optic axes would not be as far beyond the pictures, and the difference in distance between the point of convergence and that of accommodation would not be so great, and the violation of the habit consequently not be so decided. For the same reason, by cutting a stereograph apart, and sliding one picture partially over the other, the experiment will often succeed on first trial.

In these cases of *ocular* combination, so called in contradistinction to the instrumental combination, of stereoscopic pictures, it is plain that the angle formed by the optic axes is less than if they were converged to the point of accommodation; or we may say the eyes are rolled outward more than is natural for the distance of the picture observed. There is, however, another *ocular* method, and one which is generally suggested first, and with a preference, namely, by *converging the axes to a point between the eyes and the pictures*, or by squinting. In this case the pictures must be transposed, as will be evident upon inspection of the figure, fig. 7, in which R′ and L′ represent the right and left eye pictures, respectively, of fig. 5 and fig. 6, but in transposed positions. The axis of the right eye, R A′, crosses the axis of the left eye, L A, when the eyes are directed to the corresponding points, A′ and A, of their pictures. In order to use ordinary stereographs in this way they must be cut apart, or drawings similar to fig. 6, which is half the natural size, may be made, in transposed positions. It will be of great assistance, in first attempts at combination by this method, to hold a pencil a short distance, say 10 inches, from the eyes, and whilst looking at it to introduce the stereograph beyond it, and move it back and forth until combination is effected as in the previous case.



In either of these cases the appearance of relief may be explained, not only by saying that proper dissimilar retinal impressions are pro-

duced, as in looking at an object, but on the theory of successive convergency of the optic axes before given, although it may be best to state here that it will be found necessary subsequently to modify somewhat this theory. It is, however, correct enough in its general features to justify its use in this connection.

Thus, in fig. 5, the optic axes form a smaller angle with each other when directed to a and a' than when directed to c and c', just as they do in case of the points A and C of the real object; or, we may say, the eyes are rolled inward when the axes are turned from the points a and a' to the points c and c' of the pictures, just as when turned from the point A to the point C of the object. When the method of convergence to a nearer point is employed, it will be apparent, from fig. 7, that a similar movement of the axes takes place.

If it be conceded that the method of convergence to a nearer point is more readily acquired, as is generally stated, although the writer is not conscious of the difference in his own case, the explanation would seem to lie in the fact that the points of accommodation and convergence more nearly agree in the one case than in the other; for, when the similar points are separated by nearly the interocular distance, the axes in passing through them will be nearly parallel, the point of convergence will be at a great distance; but in the second method the point of convergence will lie between the eyes and the pictures, and therefore much nearer to the latter, whilst the eyes in both cases must be accommodated to the same distance, namely, the plane of the pictures.

But statements are frequently made, in this connection, by some of the best authorities on the subject of Binocular Vision, which are calculated to mislead, and to prevent individuals from enjoying and cultivating the power of combining pictures by the first method. Thus, Sir David Brewster remarks: "The distance in this case must be greatly less than the distance of the eyes, in order that the optic axes, in passing through similar points of the two plane pictures, may meet at a moderate distance beyond them," (p. 83.) "We cannot thus unite figures the distance of whose centre is equal to or exceeds two and a half inches," (p. 97). "It is impossible to obtain by the ocular stereoscope pictures in relief from the beautiful binocular slides which are made in every part of the world for the lenticular stereoscope," (p. 123). In his able and exhaustive papers on Binocular Vision (Silliman's Journal, new series, vols. xx and xxi), Prof. Wm. B. Rogers states: "In this mode of combination, the picture of the ob-

ject proper to the right eye is viewed by that eye, and the picture proper to the left eye by the left, just as with the common stereoscopes. Hence the drawings intended for the latter instruments may be used in this, provided they are so close to one another as to bring the points which are to be united nearer together than the centres of the eyes," (xx, p. 92.) The instrument alluded to consists essentially of a thin strip of wood, with a sliding stage to hold the stereograph whilst viewed by the *unaided* eyes. In his recent "Notes on Light," Professor Tyndall says: "The impression of solidity may be produced in an exceedingly striking manner without any stereoscope at all. Most easily thus:" Here follows a description of an experiment by the second method, and then, without alluding to the first method: "For this experiment the drawings are best made in simple outline, and they may be immensely larger than ordinary stereoscopic drawings." In another place, Sir David Brewster, in speaking of the method first given, remarks: "This tendency to a distant convergency is so rare that I have met with it only in one person." And, without alluding to the dissociation of the axial and focal adjustments of the eyes in connection with this difficulty, he dwells mainly on this fact of distant convergency.

The assumption implied in the foregoing quotations of the necessity of convergence of the optic axes to a positive point, either before or behind the slide, in every case of combination of supplementary pictures, and the consequent limitation of the distance of separation and size of the pictures, seems to originate mainly in the fact that in all cases of vision of an actual object the axes do so converge, and the tendency in writers to locate the resultant solid image at the point of convergence of the optic axes, is perhaps partially due to the same fact. According to the individual experience of the writer, and observation in cases of many others, the optic axes need not necessarily converge to a positive point, but may be parallel or even divergent. In these latter cases there would, of course, be no point of convergence at which to locate the resultant.

It seems, indeed, that the angle of convergence is not a criterion of absolute distance, but that the variation of the angle simply affords the means of comparing distances. The assumption alluded to must be founded either upon the hypothesis that it is impossible to render the optic axes parallel, as would be necessary when the similar points should be the interocular distance from each other, or divergent, as would be the case when the identical points were farther than that dis-

tance from each other, or that when the axes are in either of these positions, and the supplementary pictures presented so that the axes may pass through similar points, no union attended with the usual affect can take place. A difficulty of the first kind would only lie in overcoming an unvarying habit of concert of action of the eyes; for, as before stated, the eyes are capable of an outward movement of about ninety degrees. The second hypothesis would be met by facts to the contrary. Many persons can unite the ordinary binocular slides, even when the pictures on them are three inches apart. In fact, it requires but little practice for most individuals to do so.

The suggestions made to aid in uniting the pictures by looking at a distant object, and introducing the stereograph between it and the eye, could not, of course, apply when the distance between the similar points was greater than the interocular distance. In some cases, when individuals have succeeded in the experiment with the pictures at this distance from each other, it has been after staring at the pictures as if gazing into vacancy, as is done sometimes in resting mind and body, or when the mind is abstracted in thought, and persons and things are stared at but not noticed, the visual organs being inactive. It would seem, therefore, that the state of rest of the optic axes, or the normal state, is one of parallelism, convergence the habit when active. But, after the power has been acquired, as previously directed, it will be found that the pictures, if cut apart, can be gradually separated, and the axes will remain fixed upon the pictures, and follow them, whilst the eyes will retain their accommodation to them. The observer will be unconscious of any change, the whole effect will be unmarred, until a separation of three or even more inches is reached. According to the experience of the writer, in a series of experiments on this subject, after a separation of three inches has been passed in the above experiment a change will be felt, and probably during the first trial all will become confused at three and a half inches, but up to that point the stereoscopic effect will be complete. By practice, however, the power was acquired of uniting the ordinary binocular slides as readily without as with an instrument, and by the method just given experiments made upon the limit of separation of the pictures in his case, and afterward by larger photographic pictures prepared for the purpose. It was found at first that it required effort to overcome three inches, but by prolonged practice at different times the distance was increased to four inches. Exercise of this kind is, however, uselessly severe; further experiments in direction of in-

crease of distance were therefore abandoned, and the limit in course of a few months receded to three and a half inches. After an hour's exertion, as above, great difficulty was experienced in reading; it required conscious effort to prevent the letters from becoming double: the habit of converging the optic axes to the point of accommodation had been so broken that it became necessary to retain them in position by a decided effort. In reading old books, the old-fashioned s's were peculiarly annoying, as they invariably doubled; and when anything unusual or difficult was met with—as, for example, the rendering of a word in translating—the eyes immediately attempted to assist in overcoming it by turning the axes in all directions, causing the words and letters to march and countermarch from right and left. No such effect results from a moderate amount of exercise in using the ordinary stereographs. The weariness of the eyes in all the preceding cases does not seem to be wholly due to the unusual character of the operation, but in part to the fact that the eyes notice many details when supplementary pictures are combined that would otherwise be neglected, perhaps, even in looking at the scene itself. To take an extreme case: a line may appear to be a blemish, in a single picture: it may appear to have no position, by reason of perspective; but, by binocular examination of the two pictures, it may turn out, perhaps, to be a twig, which extends far into the foreground, all other parts of the tree having been cut out; thus there may be dots which turn out to be leaves, and so forth. The eyes, instinctively, as it were, run over and study these exceedingly more multitudinous and minute than pre-Raphaelite details of the photographic representations, they work rapidly and severely, and soon become fatigued.

The bearing of the facts just given upon the theory of binocular vision will be noticed hereafter.

ON THE SOLUBILITY OF SOME FORMS OF PHOSPHATE OF LIME.

By Chas. P. Williams,

(Late Prof. of Chemistry Delaware College.)

Director Missouri School of Mines.

Agricultural experience has long appreciated the difference in the rapidity of action of ground bones on the one hand and of some of the phosphatic guanos on the other. The decided preference given to the first form of phosphate of lime and to the various manipulated guanos and so-called superphosphates is not merely the result of

prejudice, but is in exact accordance with the results obtained by chemical experimentalists who have shown that the solubility of tri-calcic phosphate in water containing carbonic acid is as various as the source from which it is obtained. Bischof has shown* that while one part of apatite will dissolve in 393,000 parts of water saturated with carbonic acid, the artificially prepared basic phosphate requires only 1,102 parts of the same for its solution. As theoretical considerations would appear to indicate that all forms of phosphate of lime must pass to a condition corresponding to that of the artificially precipitated phosphate before assimilation by vegetation, the rapidity of the action of carbonic acid water in rendering phosphates soluble becomes an indication, measurably, of the relative rapidity of their action when applied as fertilizers, and hence of their comparative values in such capacity. Analytical investigations in this direction would seem to be of more immediate practical value than the simple quantitative determination of the constituents of a phosphatic guano or fertilizer, and may yet serve to harmonize some of the apparent discrepancies now obtaining between the results of the laboratory and the farm. Condition of molecular aggregation, determined by solubility in carbonic acid water, is of, at least, equal importance as percentage richness in phosphate of lime, and a rapid and reliable analytical method that may discriminate between such conditions of aggregation in superphosphates is a desideratum alike to chemists, manufacturers and farmers. Justice to all parties concerned makes it imperative that the analyst of an artificial phosphatic guano should distinguish between the original insoluble phosphate of lime and that which has become such by reactions in the article in question, and until this is done the analytical estimations of soluble and insoluble phosphoric acid fall short of furnishing fully reliable data for estimating commercial value. And this is equally true of natural or unmanipulated guanos.

The writer has endeavored to determine the solubility of some of the best known forms of natural tri-calcic phosphate by operating in the following manner: A weighed amount of the finely pulverized material was placed in a measured quantity of water (1000 cubic centimetres), and carbonic acid gas passed through the same for fifty hours at a temperature of 60°—70° Fahr. At the end of this time the liquid

* Elements of Chemical and Physical Geology, Cavendish Edition, Vol. iii., page 27.

was filtered off, nitric acid added to strong acid reaction, the solution concentrated by evaporation and the phosphoric acid separated by means of molybdate of ammonia. The precipitate thus obtained was treated in the usual manner to convert the phosphoric acid into ammonio-magnesic phosphate, care being taken to allow the solutions in which this was forming to stand at least twelve hours before filtration. To avoid loss, the ammonia water used for washing was in all cases made of uniform strength, the amount used in each analysis was measured, in connection with its proper filtrate, and for each 54 cubic centimetres of the liquor, ·001 grm. was added to the weight of the pyrophosphate of magnesia obtained. This correction for the solubility of ammonio-magnesic phosphate in ammoniated water was made in all cases. To render the conditions of the experiments as nearly as possible uniform, the amount of phosphate of lime present was made identical in each case, an analysis of the sample being previously made and a proportionate increase or decrease of amount being taken to correspond to increased or decreased per centage o phosphate of lime.

Experiment No. I.—Apatite from near Perth, Canada, containing 89·27 per cent. $3CaO\ PO_5$. Amount taken, 0·5 grm. Solution gave ·0021 grm. PO_5, equivalent to ·0045 $3CaO\ PO_5$. This amount corresponds to one part of the phosphate of lime of apatite dissolved in 222,222 parts of water saturated with carbonic acid.

Exp. No. II.—Same as in No. I, but the material levigated. Solution gave ·0032 grm. phosphoric acid, equivalent to ·0071 grm. $3CaO\ PO_5$ or one part in 140,840 parts of water saturated with carbonic acid.

Exp. No. III.—Fine ground and pure bone containing 56·78 per cent. of phosphate of lime. Amount taken, 0.733 grm. Solution gave ·0804 grm. phosphoric acid, equivalent to ·1753 grm. phosphate lime. One part of the phosphate of lime in raw bones dissolves in 5698 parts of water saturated with carbonic acid. According to Bischof* fresh ox-bone shavings require 4,610 parts, while Liebig† says only 1,500 parts of carbonic acid water are required.

Exp. No. IV.—To determine whether the organic matter of the bone had any influence on its solubility, a portion of the material used in III was calcined and the organic matters burned off. The ash corresponded to 61·13 per cent. of the original bone and, therefore,

* *Loc. cit.*

† Quoted by Bischoff, *loc. cit.*

contained 92.88 per cent. of tri-calcic phosphate. Amount of bone ash taken, ·4805 grm. Solution gave ·0569 grm. phosphoric acid, equivalent to 0·1246 grm. phosphate of lime, or one part in 8029 parts of water saturated with carbonic acid.

Exp. No. V.—A sample of adulterated bone dust of commerce, containing 24·32 per cent. organic and volatile matters, 35·06 per cent. phosphate of lime and 26·13 per cent. of sulphate of soda (salt cake with a small amount of acid sulphate). Amount taken, 1·3157 grms. Solution gave 0·1111 grm. PO_5, equivalent to 0·2426 grm. $3CaO\ PO_5$—or one part in 4,122 parts carbonic acid water. The greater solubility of this sample is, in all probability, due to the formation of some acid phosphate of lime ($CaO\ 2HO\ PO_5$) by the small amount of free sulphuric acid present in the salt cake with which it was adulterated.

Exp. No. VI.—South Carolina phosphate, from the property of the Charleston Mining and Manufacturing Company, containing 57·89 per cent. phosphate of lime. Amount taken, 0·771 grm. Gave PO_5, ·0647 grm., equivalent to ·1413 grm. $3CaO\ PO_5$, or one part in 6983.

Exp. No. VII.—Same as No. VI, but levigated; gave ·1528 grm. $3CaO\ PO_5$, or one part in 6544.

Exp. No. VIII.—Phosphatic guano from Orchilla Island. Containing moisture 12·88 per cent.; organic and volatile matters 14·60 per cent.; $3CaO\ PO_5$, 49.67 per cent.; $CaO\ CO_2$, $CaO\ SO_3$, sand, clay, etc., 22·76 per cent. Amount taken, ·8970; gave 0.0588 PO_5, equivalent to 0·1248 grm. $3CaO\ PO_5$, or one part in 8009 parts of water saturated with carbonic acid.

Such well-known guanos as the Narassa and Swan Island were not experimented with on account of their larger per centages of phosphates of iron and alumina.

It is not claimed that these results will indicate the absolute degree of solubility of the several materials in the soil when the water is not saturated with carbonic acid and where there are so many modifying and controlling conditions, but they serve to indicate, with some degree of exactness, the relative rapidity of action of the different forms of phosphate of lime, and to show the wide range of solubility of the compound under similar conditions, according to the source from which it is obtained. They, perhaps, rather enhance than decrease the difficulties in the way of discriminating between the chemically precipitated and the original undecomposed phosphates of a

"superphosphate" by throwing suspicion on the absolute exactness of all those methods of separation based upon solubility in weak or organic acids, unless indeed, the operator is acquainted with the raw materials employed by the manufacturer of such "superphosphate." They and all similar experiments, however, fix the great value of this precipitated or "returned" phosphate, by showing how much more rapid it is in its action than is any form of phosphate, to whatever degree of fineness it may be brought by purely mechanical means of subdivision.

Missouri School of Mines, Rolla, Oct. 16th, 1871.

ON MR. CROOKES' FURTHER EXPERIMENTS ON PSYCHIC FORCE.

By P. H. Vanderweyde, of New York.

Mr. Crookes gives, in the last number of the *Quarterly Journal of Science*, some "further experiments on psychic force." It turns out now, that when twelve months ago he announced that he "was about to investigate the phenomena of so-called spiritualism," he had already been converted to this delusion, because now he says: "I have been working at the subject for two years, and have found nine or ten different persons who possess psychic power in more or less degree." Consequently, in beginning the investigation, twelve months ago, he discarded the golden rule of Descartes, the first sentence in his philosophy, namely, "In order to arrive at the knowledge of the truth it is our duty to commence with doubting everything." Mr. Crookes did not doubt twelve months ago, but started then with the belief that there are really persons who possess the so-called psychic power, which, as appears from his further elucidations, consists chiefly in increasing the action of gravitation. For instance, he says "objects varying in weight from 25 to 100 lbs. were temporarily influenced in such a manner that I and others present could with difficulty lift them from the floor."

To this I remark that it is a common experiment by so-called psychologists to let people try to lift heavy weights, influencing, at the same time, their mind in such a manner that they imagine the weight has considerably increased. I have myself witnessed exhibitions where strong men declared they could not lift a psychologised weight at all, and I am confident they were honest; but it was not the weight which was psychologised, but their minds and imagination; this was

it which influenced and partially paralyzed their muscular efforts. In all such cases I myself never had the least trouble in lifting the weights, and never found any difference in their gravity, even when a dozen persons testified to the contrary; the simple reason of this is my unflinching faith in the universal law of gravitation and my firm conviction of the absurdity of the hypothesis that these laws could be changed by certain individuals—in short the total impossibility of psychologising my mind. During some such experiment I had the weight suspended from a large balance and placed in equilibrium with a counterpoise, but then no medium ever succeeded in increasing or diminishing it a single ounce. The believers, however, as well known, are ready for such an emergency: my "unbelief disturbed and neutralized the physic force of the medium."

I am indeed surprised that Mr. Crookes experiments exclusively with the unreliable spring balances, which he surely does not use in his chemical investigations. Nothing is easier than to practice deception with the same, for which reason a certain class of traders use them exclusively, and for the same reason their use has been forbidden in some countries. Why does Mr. Crookes not make use of his old honest chemical balance? No doubt he has at least one in his possession much more delicate than the apparatus he describes, which, for the possessor of a good balance, is totally unnecessary. I have one which, when charged with a 100 grammes, will be immediately affected by a milligram and indicate plainly a tenth of this, or one-millionth part of the charge. I have repeatedly challenged psycologists to influence my weights, but they never were able to add one single milligramme or to disturb the equilibrium by the effort of their will, notwithstanding my balance is so sensitive that the animal heat of the body, when sitting long at one side in making a series of weighings, exerts a decided influence.

If the use of the ordinary balance is objected to on the ground that the psychic force would act equally on both weights, I answer that, by Mr. Crookes own showing, this supposed force fluctuates so much that it is exceedingly improbable that it would act with such perfect equality on two distant weights as to show no motion in a sensitive balance. Besides it would be an easy matter to construct a balance of which the beams are so long as to bring the counterpoise beyond the influence of the psychic force; suppose it is not asserted that this influence acts equally all around the medium to any distance.

Mr. Crookes, in confirmation of his views, relates a few cases of similar experiments by Gasparin, Thury and Dr. Hare. If the first two have no more foundation than the latter the testimony is worthless. It shows only a prejudice in Mr. Crookes' mind to attach any value to the report that Dr. Hare communicated the details of his experiments to the American Association for the Advancement of Science at the meeting in August, 1855. I was present at that meeting; it was held in the city of Albany; and I declare that the apparatus was the grossest piece of self-deception one can imagine. The fact was the eminent man had become insane; the meeting would not listen to him, on the ground that his theory of spiritualism was on a religious subject or a delusion, and that in either case it was totally foreign to the field of a scientific association. On the same ground I had several years before often succeeded in keeping spiritualism out of the discussion of some scientific societies in New York. The new names invented for it—biological psychic, ectenic, nervous or vital force—are nothing but attempts to introduce this deception to the attention of scientists, under the pretext that it originates by a new. unknown force.

I close with a few serious objections to the manner of experimenting adopted by Mr. Crookes. When he traces his curves of variable pressure, for instance, he sets the clock going when Mr. Home gives the word, and does not keep it going before Home exerts his pretended influence, in order to see if the same curves are not being produced previously by some other, unnoticed cause. Again, another person put his hand on Mr. Home's hand; this is under pretext to find if Mr. Home exerts pressure, while, in fact, there are now two hands pressing; it is even stated that sometimes his hands and feet were firmly grasped, etc. There is too much interference or rather resistance there; it reminds me of one of the many psychological exhibitions I witnessed in New York, when six strong men were ordered to keep a small table down, which, it was said, would be raised from them by the spirits. They kept it down so powerfully, and in their attempts, continually encouraged by the psychologist, twisted it so from its legs that it broke up into splinters, while the audience wondered at the great force exhibited by the spirits.

Prof. Crookes complains that his testimony is not believed in this case, and his veracity questioned, while he is accustomed to be believed without witnesses. It is surprising that he does not perceive the difference in the two cases; when he published investigations con-

cerning his valuable chemical discoveries, there was nothing contradictory to the experience of any one, but when he comes to relate his experiments on psychic force he makes assertions so contrary to the experience of every man's whole life time, that he reasonably cannot expect to be implicitly believed; he ought to know that the faith of the world in the most eminent scientific men does not go so far as to the belief in their infallability.

I have not investigated this matter for two years, but for twenty-two years, and I am known in this part of the world as one of the strongest opponents to all such delusions. I have very often exposed the trickery and deception, but always declared that I am open to conviction, and have always been ready to be present when experiments in this line were made. As I have but one desire, *to know the truth*, and but one fear, *to believe an error*, I will be the first to acknowledge it when I shall be convinced of the reality of the existence of a psychic force which can influence the gravity of bodies. To do this, however, I do not trust tricky spring balances, but my own chemical balance, my trusted friend, who never in my life deceived me. The microscope and telescope may deceive, the spectroscope may give deep problems to solve, but the balance is the only perfectly truthful and reliable adviser of the scientist. Demonstrate the reality of the psychic force with the balance, Mr. Crookes—measure its intensity in grammes—then we will have something tangible, and the whole scientific world will be convinced of the reality of another force besides the forces already known, and a new subject for research.

NOTES ON THE COLOR OF FLUORESCENT SOLUTIONS.

By Prof. Henry Morton, President of Stevens Institute of Technology.

No. II.

I have recently observed a curious action, which, while it in no respect affects the general conclusions given on page 140 of the present volume of this journal, nor the main observations on which they were founded, throws out one of the corroborative experiments by which I thought that they might be established when a spectroscope was not at hand.

Obtaining some very anomalous results of late, I was led to mistrust the action of the geissler tubes in which the solutions had been examined.

These were of the ordinary kind of jacketed spirals, selected as being nearly identical in size and other particulars.

It had been observed from the first that the internal spiral gave a faint blue fluorescence, which could only be seen on close inspection, and in all cases the tube being but partly filled, it was considered that a light appearing in the part covered by the fluid, many times more bright than that from the uncovered part of the spiral, was sufficient evidence of fluorescence in the liquid.

Late experiments have, however, proved that this was not so. Any liquid, however devoid of fluorescent properties, gives all the appearance of fluorescing in these tubes, and on a little thought the cause of this became clear.

The only fluorescent light that can be seen from the glass of the spiral is that which comes off tangentically from the outer surface, the foreshortening increasing its effect, while, moreover, that emitted radially is masked by the bright electric discharge behind.

In passing from the glass to air, most of this light will suffer total reflection at the outer surface of the glass; but if water or any other liquid is substituted for the air, its greater refracting power (approaching that of glass) will diminish the above-named action, so that much more of the light will reach the eye. The truth of this explanation was supported by the observation that the nearer the index of refraction in the liquid came to that of glass the brighter was the light seen through it.

This fact renders of no account the observations before made on filtered and diluted solution of turmeric, but a fresh observation with the spectroscope on tubes free from fluorescence has fully confirmed my former conclusions as to the true color of fluorescence in this liquid.

No correction need be applied to the case of the description already published in the asphalt solution, but I may add to what was there stated another striking example:

If one of the little geissler tubes containing nitrogen, called "spectrum tubes," be jacketed by means of a perforated cork and a large glass tube, and the jacket filled with pure or non-fluorescent benzine, then illuminating the tube, and with a pipette dropping in that petroleum product called "cosmoline" (a lubricating oil made by E. H. Houghton, of Philadelphia), each drop will appear of a rich blue as it dissolves in the benzine, which soon acquires a magnificent blue fluorescence. Increasing, however, the quantity of cosmoline oil un-

til its color begins to take effect, the tint of the fluorescence gradually changes to a rich green.

By a little care a blue solution may be superposed on a green one in the same tube.

Another semi-solid preparation of cosmoline, which has a very light color, gives a solution with benzine fluorescing of a magnificent blue.

I have this substance now under investigation, and hope soon to be able to make some further observations upon it.*

Returning to the solutions of turmeric, I have found that the fluorescent body in that substance is not its essential oil, nor its brown coloring matter, but either the yellow coloring matter itself, or something so closely allied to it in solubility, that I have thus far been unable to effect any separation.

In connection with this, I am much indebted to Mr. Robt. F. Fairthorne, of Philadelphia, who has aided me greatly in the preparation of the various constituents of turmeric in a state of purity.

In my former paper I mentioned that uranium nitrate in solution gave a very faint fluorescence.

This appearance I now find was due entirely to the above explained action of the tube, and a number of carefully conducted observations now convince me that this substance, while it fluoresces so vividly in the solid state, loses that property entirely when in solution.

I have also found that a saturated solution of acid quinine sulphate had its fluorescence much *increased* by dilution.

Let me remark, in conclusion, that I would by no means assert that all solutions fluoresce blue, but simply that a number already specified, and generally credited with other colors, possess this property.

* Mr. Houghton tells me that "cosmoline" is prepared from crude petroleum, by evaporation *in vacuo* and filtration through animal charcoal only, without any chemical treatment.

Bibliographical Notices.

A Manual of the Principles and Practice of Road Making; comprising the Location, Construction, and Improvement of Roads, Common, Macadam, Paved, Plank, etc., and Railroads. By W. M. Gillespie, LL.D., C.E. Tenth edition, with large addenda. Edited by Cady Staley, A.M., C.E. A. S. Barnes & Company, New York and Chicago. 1871.

We regret our inability to commend the typography and general style of getting up of this book, which is defaced by deficiencies in the printing and final revision of proofs. The first edition—1847, had an extensive circulation, and has been constantly followed by others, until we now have the tenth before us. This commercial success indicates, we think, deserved popularity in a work which supplied an obvious public want by furnishing within moderate compass a useful practical manual of road making, without excluding appropriate mathematical formulæ which assist to explain its rules. The steady circulation of the work has made former editions of it so familiar to our readers interested in road making that they will scarce expect of us an effort to appreciate its merits thoroughly and assign its place in professional literature, but rather a sketch of the additions which have been made. The first edition contained 336 octavo pages; the present one contains 464 pages of the same kind, showing a gain of 128 pages of the original size. Of this increased bulk 20 pages are added to the article on "Plank Roads," which the author considers as "the most valuable improvement since Macadam's, and one superior to his in many localities." "What Railroads Ought to Be," in respect of direction, grades, width of gauge, and other features, gains 8 pages. The comparative advantages of broad and narrow gauge railroads are discussed, and the preference given to the narrow gauge, in order to prevent a "break of gauge," although a gauge of 5½ or 6 feet is considered desirable theoretically; but the "narrow gauge" here alluded to is the gauge of 4 feet 8½ inches, and not the "narrow gauge" as understood in relation to such roads as the Festiniog Railway in Wales, and which has recently much occupied public attention. The "narrow gauge question," in this sense, is not touched upon. "Working Expenses" gains 1 page; the tabular statements cited are of the year 1851. All this makes a gain of 28 pages in the main text, which in other respects stands as in the first edition, except, perhaps, very

slight alterations. The remaining increase of about 100 pages is in the "Appendix," divided into several heads. Here the calculation of "Excavation and Embankment" gains some 30 pages, of which 15 are occupied by a valuable memoir, published in this *Journal*, 1857—1859, and 4 pages of tables from those of Macneil, to whom the writer appears to give preference in this respect. "Location of Roads" gains 6 pages; laying out of "Curves," 24; "Estimation," 4; "Tunnels," 3; "Bridges," 23; "Specifications," 3; "Railroad Resistances," 5; and "Staking out Side Slopes," 3. In our opinion, the work would have been improved, and the claims of the public, after such long patronage, better satisfied, by appropriately disposing of all or most of the matter contained in the addenda within the body of the work. Our readers, we hope, will understand that our strictures are not meant to apply to the labors of the author, but solely to what seems to us to be inferior mechanical execution and insufficient editorial arrangement and revision, for a standard professional Manual.

ERRATA *in Professor Young's "Spectroscopic Notes" (published in the last number of this journal).*

P. 149, lines 9 and 10 from top, for reflected read deflected.

P. 355, line 12 from bottom, for co-efficient of dispersion, read co-efficient of deviation.

P. 356, line 1 from top, for $D = m\,n\,s\,\partial\,f'.\,d\,\mu$, read $\mathrm{D} = m\,n\,\partial\,f'.\,d\,\mu$.

Page 358, line 10 from top, for $\mathrm{A} = \dfrac{l m n \triangle f_1^2}{f}$ read $\mathrm{A} = \dfrac{l\,m \triangle f_1^2}{f}$

Page 358, line 13, for $\mathrm{L} = \dfrac{i\,l\,w\,a^2 - f^2\,S}{l\,m^2\,n \triangle f_1^2 f}$ read $\mathrm{L} = \dfrac{i\,l\,w\,a^2 - f^2\,S}{l\,m^2 \triangle f_1^2 f.}$

P. 358, line 16, for $\mathrm{L}' = \dfrac{i\,w\,a^2}{m^2\,n \triangle f}.3$, read $\mathrm{L}' = \dfrac{i\,w\,a^2}{m^2 \triangle f^3.}$